(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 February 2007 (22.02.2007)

PCT

(10) International Publication Number
WO 2007/019628 A1

(51) International Patent Classification:
A61M 16/00 (2006.01) *A61M 16/16* (2006.01)

(21) International Application Number:
PCT/AU2006/001173

(22) International Filing Date: 15 August 2006 (15.08.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/707,951 15 August 2005 (15.08.2005) US

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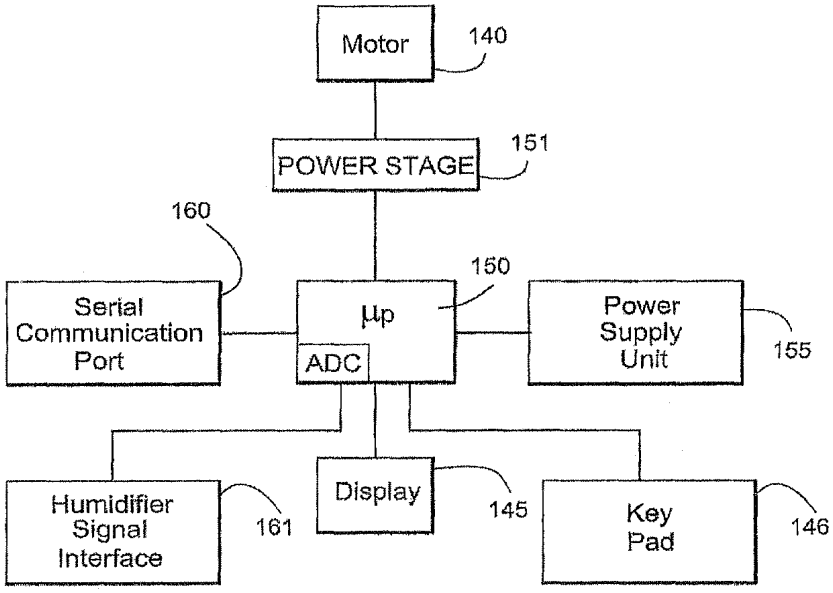
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,

[Continued on next page]

(54) Title: LOW COST CPAP FLOW GENERATOR AND HUMIDIFIER ASSEMBLY



(57) Abstract: A CPAP device wherein humidification detection and/or control is performed by a microprocessor of the CPAP device without requiring a separate humidification control chip. The microprocessor (150) may also control the flow generator motor (140) and the flow generator display (145). Further, the microprocessor may include code to prevent "brown-out", and/or to detect the availability (connection and/or operability) of the humidifier. Humidifier detection may be carried out using power consumption or temperature sensor signal analysis, e.g., facilitated by use of a pull-up resistor.

WO 2007/019628 A1

RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

LOW COST CPAP FLOW GENERATOR AND HUMIDIFIER ASSEMBLY

CROSS-REFERENCE TO PRIORITY APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 60/707,951, filed August 15, 2005, incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a low cost Continuous Positive Airway Pressure (CPAP) device used to treat sleep disordered breathing (SDB) conditions such as Obstructive Sleep Apnea (OSA). In particular, the present invention relates to a low cost CPAP flow generator and humidifier assembly.

Background of the Invention

[0003] Since Sullivan's invention of nasal CPAP treatment of "snoring sickness", treatment systems have become quieter and more comfortable for patients. Typically, a patient is tested by a sleep physician who titrates a treatment pressure for the patient, and the patient is sent home with a basic low-cost CPAP device that is set to, and remains at, that treatment pressure. While more sophisticated devices exist that can to some extent automatically titrate, the majority of patients are treated with a basic low-cost CPAP device. A basic CPAP device comprises a blower that can provide a supply of air or breathable gas at pressures in the range of 4 cmH_2O to 20 cmH_2O. There is a constant need in the art to reduce cost while providing the same functionality.

[0004] A common configuration of a treatment system comprises a CPAP device and a patient interface, typically a nasal mask. The nasal mask forms a sealing interface with the patient's nasal passages in use so that the supply of air at positive pressure from

the CPAP device is delivered to the patient's airways. While the patient is wearing a nasal mask, their mouth is uncovered.

[0005] In some situations, patients "mouth breath" during sleep. When this happens while wearing only a nasal mask, air can pass in the mask and straight out the mouth. This can lead to drying of the airway and patient discomfort. This patient discomfort can to some extent be alleviated by the use of a humidifier placed between the CPAP device and patient interface.

[0006] Many humidifiers are available, although the most convenient form is one that is either integrated with or configured to be coupled to the relevant CPAP device. While passive humidifiers can provide some relief, generally a heated humidifier is required to provide sufficient moisture to the air so that patients will be comfortable. Humidifiers typically comprise a water tub having a capacity of several hundred milliliters, a heating element, a control to enable the level of humidification to be varied, an air inlet to receive air from the blower, and an air outlet adapted to be connected to an air delivery conduit so that the humidified pressurized air may be passed to the patient interface. Usually, the water tub is removable from the system so that it can be refilled when necessary.

[0007] Often patients may start with a CPAP flow generator/blower and later desire to include a humidifier. However, not all patients require humidification. Thus there is a commercial advantage in having a system that allows a patient to start with a flow generator and later choose to upgrade to a humidifier at low cost.

[0008] The cost of producing equipment is influenced by a number of factors including parts, labor, factory overhead, packaging, transport, and distribution costs and taxes. Labor costs can be reduced in a number of ways, such as by designing for simple, low cost manufacture. For example, a design that calls for fewer parts is quicker, simpler and cheaper to manufacture. A design that uses cheaper parts is likewise cheaper overall.

[0009] There is a spectrum of humidifier/CPAP device coupling configurations from fully integrated to completely separate. In between these end points, there is a range of intermediate configurations.

[0010] Moreover, peripheral components such as a humidifier can be more expensive since they typically include hardware and other expensive components and controls which are necessary for communication with the basic CPAP device.

[0011] By way of example, in a completely separate configuration there is only a hose delivering a supply of air at positive pressure between the CPAP device and humidifier, and there are no electrical signals between the two devices, such as control or sensing signals. While the CPAP device might be able to discriminate the presence of the humidifier by an increase air impedance on the hose, there is no signal sent between the two devices to advise the CPAP device of the presence of the humidifier. Furthermore, all heating and humidification controls reside on the humidifier. Power must be separately supplied to the humidifier. An example of such a humidifier is the ResMed HUMIDAIRE™ humidifier.

[0012] An example of a system using an intermediate configuration is ResMed's S7 CPAP device. In this system, the CPAP device can be used without any humidifier. However, if the front panel of the CPAP device is removed, a specific humidifier, e.g., the ResMed H2i™ humidifier, may be connected. There are a number of electrical and mechanical connections between the CPAP device and humidifier. Power for the heater is supplied from the CPAP device and hence there is no separate power cord for the humidifier. Humidification controls reside on the humidifier.

[0013] In a fully integrated system, the humidifier is not removable from the CPAP device (although the humidifier tub may be removable to facilitate refilling).

[0014] Other known systems include Fisher & Paykel's PCT Application no. WO2004/043528 and Respironics' RemStar AUTO product.

[0015] In summary, there is a need in the art to provide a basic low-cost CPAP device which is upgradeable with a suitable humidifier.

BRIEF SUMMARY OF THE INVENTION

[0016] One aspect of the invention is to provide a low-cost CPAP flow generator/blower and humidifier assembly. Another aspect of the invention is to provide

a CPAP flow generator/blower that has an optional low-cost upgrade to humidification. Another aspect of the invention is to provide a CPAP flow generator/blower and humidifier assembly in which humidification control is provided on the flow generator rather than on the humidifier or humidifier tub. The humidifier tub may be detachable from the flow generator and/or the common support cradle.

[0017] Another aspect of the invention relates to a low-cost CPAP having software based control of a humidifier having a tub that may be detachable from the flow generator, e.g., using the same microprocessor of the CPAP for multiple tasks – multi tasking and resource sharing of one CPU - such as CPAP motor and/or therapy control, humidifier detection and/or control and/or user interface control.

[0018] Another aspect relates to the provision of a CPAP device with reduced componentry but without the sacrifice of reduced functionality.

[0019] Another aspect relates to a low-cost, low-memory capacity microprocessor for a CPAP device which is configured to control one or more auxiliary components via software based control.

[0020] Another aspect relates to a CPAP device including native control systems, e.g., based on software, for later added components or accessories, such as a humidifier. Such a control system can take the form of code that is written in the CPAP device's microprocessor. The code of controlling the humidifier can take up as little as 100-150 bytes of memory.

[0021] Another example of the invention relates to a low cost and easy to use humidifier. The humidifier/tub need not include a control system or even control knobs, the operation and/or functionality of each of which may be provided in a CPAP device instead. Further, the humidifier/tub can simply include low power and low cost switches. In a preferred embodiment the power control switch is on the humidifier/tub but the software control of this switch is in the flow generator. This design ensures that the cost of the switch is carried by the humidifier/tub and not the flow generator. There is minimal additional cost to the flow generator in having the software control of the humidifier incorporated in the flow generator.

[0022] In one example, the invention includes a CPAP device wherein humidification control is performed by a microprocessor of the CPAP device without requiring a separate humidification control processor. Motor control and display control can be performed by the microprocessor without requiring a separate motor control processors and display control processors.

[0023] In another example, a CPAP device comprises a flow generator including a microprocessor with an analog-to-digital converter (ADC); a humidifier tub detachably coupled to the flow generator; and a temperature sensor in communication with the humidifier and adapted to produce a signal (voltage is an example of a signal that may be provided to the flow generator, but other types of signals such as a current signal or an optical signal may also be used) provided to the flow generator microprocessor via the ADC, wherein the microprocessor is programmed with a humidifier control program to control power supply to the humidifier in accordance with output of the temperature sensor. The ADC can be built in to the microprocessor, or it can be an external component.

[0024] In still another example, a method for controlling a humidifier of a CPAP device, comprises monitoring the temperature of the humidifier; generating a signal, e.g., a voltage signal, representative of the humidifier temperature; converting the signal to a digital value; applying the digital value to a microprocessor of a flow generator of the CPAP device; and supplying power to the humidifier in accordance with the digital value.

[0025] In still another example, a method for detecting and identifying a valid humidifier of a CPAP device comprises monitoring the temperature sensor output of the humidifier; generating a signal, e.g., a voltage signal, representative of the humidifier temperature; converting the signal to a digital value; applying the digital value to a microprocessor of a flow generator of the CPAP device; and enabling or disabling the humidifier function. A further aspect of the method may be to provide a message to the user, e.g., provide "new-user" interface for humidifier operation, in which case the humidifier and/or blower will provide instructions suited for a novice user. Alternatively or in addition, the message may warn the user of a non-valid humidifier or fault condition

in accordance with the digital signal. The message may also include an indication or signal that the humidifier is valid, e.g., the message may include one or more of the following: a) "correct humidifier is connected", b) "the connection of the humidifier is correct" and/or c) "the humidifier is functional". In one embodiment the indication may be in the form of a light emitting diode (LED) that signals the attachment and functioning of a valid humidifier.

According to another example of the invention, there is provided a CPAP device comprising a flow generator including a microprocessor; a motor provided to the said flow generator; and a digital circuit to detect RPM of the motor, said digital circuit including a clock timer, a counter unit and a decoder, wherein the decoder is configured to generate a signal that is indicative of RPM as a function of time. Another example of the invention covers the analog method of monitoring and optionally controlling motor speed (RPM).

[0026] Other aspects, features, and advantages of this invention will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, which are a part of this disclosure and which illustrate, by way of example, principles of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The accompanying drawings facilitate an understanding of the various embodiments of this invention. In such drawings:

[0028] Fig. 1 is a perspective view of a CPAP device according to an embodiment of the invention;

[0029] Fig. 2 is a top view of the CPAP device shown in Fig. 1;

[0030] Fig. 3 is a side view of the CPAP device shown in Fig. 1;

[0031] Fig. 4 is an end view of the CPAP device shown in Fig. 1;

[0032] Fig. 5 is a schematic diagram of an assembly including a CPAP device, a humidifier and a cradle according to an embodiment of the invention;

[0033] Fig. 6 is a schematic diagram of a heater plate according to an embodiment of the invention;

[0034] Fig. 7 is a schematic block diagram showing major electrical components of a CPAP device according to an embodiment of the invention;

[0035] Fig. 8 is a block diagram showing an example of a more complete complement of components of a CPAP device according to an embodiment of the present invention;

[0036] Fig. 9 is a graph illustrating a temperature target range defined by minimum and maximum temperatures;

[0037] Figs. 10 and 11 are program charts for controlling humidifier temperature according to embodiments of the invention;

[0038] Fig. 12 is a schematic diagram showing one example of electrical components of a cradle according to an embodiment of the present invention;

[0039] Fig. 13 is a program chart for determining availability of a humidifier or another peripheral component according to an embodiment of the invention;

[0040] Fig. 13.1 is a circuit for humidifier detection and/or control according an embodiment of the present invention;

[0041] Fig. 13.2 is a graph illustrating values that can be utilized by the microprocessor software as an indication of the operation state and/or presence of the humidifier;

[0042] Figs. 14 and 15 are schematic views of a system for detecting and monitoring a humidifier according to an embodiment of the invention;

[0043] Fig. 16 is a schematic view of a liquid crystal display (LCD) driving circuit according to an embodiment of the present invention;

[0044] Fig. 17 is a chart showing logic signal combinations for use with the driving circuit of Fig. 16;

[0045] Figs. 18-1 - 20 illustrate details of an example of an LCD according to an embodiment of the present invention;

[0046] Fig. 21 is a schematic electric diagram showing one possible circuit for driving an LCD according to an aspect of the present invention;

[0047] Fig. 22 is a graph explaining exemplary timing aspects of the series-based activation of pixels or other display elements according to an aspect of the present invention;

[0048] Fig. 23 is a process chart showing a motor speed control circuit according to an embodiment of the present invention; and

[0049] Fig. 24 is a circuit for digital motor speed detection and/or control according an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0050] 1. Overall CPAP system

[0051] Figs. 1-4 illustrate a CPAP system 10 according to an embodiment of the present invention. As illustrated, the CPAP system 10 includes a flow generator 20 and a heated humidifier 30 adapted to be coupled to the flow generator 20. The CPAP system 10 provides a low cost system having a simplified functionality, a reduced electronics and mechanical parts count, and low cost manufacture design.

[0052] 2. Humidifier

[0053] In heated humidification, air from the flow generator/ blower outlet is directed over a body of heated water picking up moisture before exiting the humidifier tub. The water is heated by being in thermal contact with a heating element. Typically control of the electrical circuit that controls the heating element resides in the humidifier. However in the present example, the control processor and most control circuitry parts reside in the flow generator.

[0054] The humidifier 30 includes a humidifier tub 50 having a base plate 52 sealed to the bottom of the tub 50. The tub 50 includes an inlet 54 adapted to be in fluid communication with (but not necessarily directly) the outlet 24 of the flow generator 20, and an outlet 56 adapted to be connected to an air delivery conduit. The air delivery conduit includes one end coupled to the outlet 56 of the tub 50 and an opposite end

coupled to a patient interface. The patient interface comfortably engages the patient's face and provides a seal. The patient interface may have any suitable configuration as is known in the art, e.g., full-face mask, nasal mask, oro-nasal mask, mouth mask, nasal prongs, etc.

[0055] The tub 50 and base plate 52 define a chamber that is adapted to receive a volume of water, e.g., several hundred milliliters (e.g., 200-500 mL). The inlet 54 and the outlet 56 are both in communication with the chamber. In use, a supply of pressurized air from the flow generator 20 enters the inlet 54 of the tub 50 and collects moisture through contact with the heated water within the tub 50 before continuing on to the outlet 56 and to the patient via the air delivery conduit.

[0056] As best shown in Fig. 2, the tub 50 may include a curved baffle 60 adjacent the outlet end of the inlet 54 to smoothly change the direction of the air flow by gently guiding the air flow around the tub 50 while limiting the loss of pressure. Also, the base plate 52 may be in the form of a heat conducting base plate. Specifically, the base plate 52 may be formed of a heat conducting material, e.g., aluminum sheet.

[0057] In an embodiment, the humidifier tub 50 may be structured such as the humidifier described in commonly-owned U.S. Provisional Patent Application No. 60/707,949, entitled "Humidifier Tub For CPAP Device", filed August 15, 2005, the contents of which are incorporated in its entirety by reference herein.

[0058] 3. Cradle

[0059] As schematically illustrated in Fig. 5, the CPAP device 10 may include a cradle 100 structured to support the humidifier tub 50 in an operative position with respect to the flow generator 20.

[0060] The cradle 100 may include a heater plate 105 that includes a heating element 110 as schematically illustrated in Fig. 6, e.g., a ceramic heating element. In use, the cradle 100 receives the humidifier tub 50 so that the heating element 110 is in thermal contact with the heat conducting base plate 52 (Fig. 3) of the humidifier tub 50. This arrangement allows water contained within the humidifier tub 50 to be heated to provide sufficient moisture to the air so that patients will be comfortable.

[0061] In an alternative, the heater element could be integrally formed with or otherwise associated with the humidifier tub 50. For example, the heater element could include a ribbon heater placed inside the tub and in communication with a power source. Such ribbon or Thermofoil heaters are commercially available, e.g., from Mod-Tronics Instruments, Limited.

[0062] 3.1 Cradle Electrical Design

[0063] Temperature sensing is preferably performed by a thermistor 115 (Fig. 6), e.g., having 33K resistance at room temperature and 1% tolerance. The cradle 100 includes a signal cable 120, an alternating current (AC) power inlet cable 125, and an AC outlet cable 130. In use, the signal cable conducts three signals between the cradle and the flow generator, i.e., a temperature sensor signal, a power signal, and a ground signal. The AC inlet cable is connected to a main power supply, and the AC outlet cable is connected to an AC inlet socket on the flow generator thereby providing power to it. Control of the heating element is performed by the flow generator Central Processing Unit (CPU) as will be described below. In this way, the electrical design of the cradle is relatively simple and inexpensive.

[0064] 4. Flow Generator

[0065] The flow generator may be a stand-alone device that produces a supply of air at positive pressure, e.g., in the range of 4 to 20 cmH_2O. The flow generator includes an electric motor that drives an impeller, a volute, a display, a power supply, a printed circuit board (PCB), and a housing. The housing provides an air inlet and an air outlet that may be directly or indirectly connected to an air delivery conduit and hence to a patient interface. When a humidifier is used, it is generally placed between the air outlet of the flow generator and the air delivery conduit as described above. As is known in the art, the impeller is operable to draw a supply of air into the housing through the air inlet and provide a pressurized flow of air at the air outlet.

[0066] 4.1 Flow Generator Mechanical Design

[0067] In accordance with an aspect of the present invention, while the humidifier is a separate component from the flow generator, humidification control is performed by

the flow generator. The mechanical connection between the humidifier and flow generator is relatively simple and can be relatively imprecise, in terms of axis alignment of the sealing elements on the flow-generator outlet and water tub, when compared to other known systems such as the ResMed S7 CPAP device and H2i humidifier. See, e.g., commonly-owned, U.S. Provisional Application No. 60/707,948, filed August 15, 2005, entitled "REMOVABLE HUMIDIFIER FOR CPAP DEVICE" and incorporated herein by reference in its entirety.

[0068] 4.2 Flow Generator Electrical Design

[0069] As schematically illustrated in Fig. 7, the main portions of the flow generator electrical design include a motor 140, a display 145, e.g., a 7 segment LCD Display, a key pad 146, a low cost microprocessor 150, a motor driving power stage 151,a space power supply unit (PSU) 155, a communications signal port 160, and a humidifier signal interface 161. In one embodiment, the microprocessor does not drive the motor directly, the microprocessor provides a driving logic signal to the power stage and then the power stage provides the power to drive the motor. While Fig 7 shows exemplary main portions of the flow generator electrical design, Fig. 8 shows an example including a more complete complement of flow generator electrical components.

[0070] In known devices, the motor commutation and safety control and the display control are performed by separate integrated circuits. For example, the motor control is performed by a Motorola integrated circuit (IC), e.g., processor, and the display control is performed by an IC, e.g., a costly customized LCD driver IC embedded in an off-the-shelf LCD module, e.g., the Hitachi HD44780U.

[0071] In contrast, the microprocessor 150 of the flow generator performs one and preferably both motor and display control functions. Bringing the motor control and LCD display control onto the microprocessor 150 reduces the number of electronic circuit parts and costs for the flow generator. In addition, as discussed in more detail below, the microprocessor 150 performs humidification control. Further, many functions traditionally performed by circuit hardware are being performed by software in the flow generator 150. A challenge that this approach creates is additional work for the

microprocessor 150 that may, in theory, require a high-powered microprocessor. However, as discussed in more detail below, all of these functions may be achieved with a relatively simple low powered microprocessor 150, e.g., the implementation memory requirements for the humidifier controller algorithm is between about 100-150 bytes.

[0072] One microprocessor that is commercially available is the ST-7, manufactured by ST-Microelectronics. There is a family of ST-7 microprocessors. One type of ST-7 microprocessor is currently used in a commercially available CPAP machine – the Kaerys KXS. However, the ST-7 microprocessor used in the Kaerys KXS is more expensive as it has a larger memory, 60K read only memory (ROM) and more input/output ports (I/O). The ST-7 used in the present invention is from the STM7 series, ST7FMC2R7T6, it is an 8 bit, 48K ROM and 1.5K RAM processor. In accordance with one aspect of the present invention, this processor can be used to record usage hours, although compliance data is not necessarily recorded and can be eliminated. An EEPROM can also be used to store motor hours. In addition, the microprocessor need not communicate with external devices (e.g., a PC, smart card, etc.), although various information can be accessed during manufacture and servicing.

[0073] 4.3 Flow Generator Software Design

[0074] 4.3.1 Humidifier heating control

[0075] A heated humidifier requires some form of control system that controls when electrical power is to be applied to the heater element. In particular, the control system should have a temperature set point or range, a temperature signal received from a temperature sensor, and a signal indicating when to activate/deactivate heating of the heater plate. Many different control schemes are possible.

[0076] In one example, the system has a valid operating range set between a minimum and maximum working temperatures, for example, 5°C and 60°C, respectively. If the temperature of the heating element is detected to be below or above the valid operating range the heater plate is inactivated. However, under these conditions the humidifier may still be used with the system as an unheated passover humidifier but there will be no power supplied to the heating element. Fig. 9 is a graph which shows a target

temperature range (T_R) which is defined between a minimum temperature (T_{MIN}) and a maximum temperature (T_{MAX}). In this example, the target range of the humidifier is between about 15-40°C although other temperatures (less than 15°C or greater than 40°C) or other temperature ranges can be used as the target, depending on the specifics of the application. The control algorithm controls the temperature not only within the valid operating range (global max-min range) but within sub-ranges in that range e.g., the user may have a setting between 1 and X, for example 3. The operational range is then divided (not necessarily equally) into temperature sub-ranges where each sub-range corresponds to one setting. Thus there would be set T_{MIN} and T_{MAX} limits for each sub-range, called local temperature limits, as well as overall or global T_{MIN} and T_{MAX} limits. In this respect Fig. 9 corresponds to one sub-range. In another embodiment, T_{MIN} and T_{MAX} may also be equal to each other such that there is a single temperature value for each user setting and the control system monitors whether the temperature is at this temperature or not. If not, the heater is either turned off or on depending upon whether the temperature is above or below this set temperature.

[0077] Fig. 10 illustrates a simple algorithm for controlling the temperature of the humidifier (T_H). In Step 1002, a determination is made as to whether $T_H \geq T_{MAX}$. This determination is based on a water temperature sensed by the thermistor 115 (Fig. 6). If "Yes", a control signal is sent to turn off (discontinue or cut off power to) the heating element 110 in the humidifier (Step 1004). If it is determined that $T_H < T_{MAX}$, a signal is generated from the microprocessor 150 to turn on (or keep on) heating element in the humidifier (Step 1006).

[0078] Following Steps 1004 and 1006, the humidifier temperature T_H is checked again to begin the cycle again of comparing to T_{MAX}, e.g., in the range of 1-10 seconds, such as every 1 second or 5 seconds. If at any time it is determined that $T_H \leq T_{MAX}$, then a signal is generated to supply power to the heating element of the humidifier. However, in accordance with a preferred aspect of the invention, power is supplied to the humidifier for only a fraction of the cycle time (Step 1008). For example, the heating

element can then be regulated to heat up at a predetermined rate, e.g., not more than 5°C/second.

[0079] For example, if the cycle time is 1 second, the power is supplied to the humidifier for less than a second, e.g. 5%-95% or 10%-100% or 1%-99% of a second. The "duty cycle" is that portion or percentage of the cycle where power is supplied to the heating element while "temperature rising rate" is dependent upon the duty and the frequency of the duty. For example, if the duty is ¼ and the frequency is 1 second then power is applied to the heating element for 0.25 seconds of every 1 second. Use of a duty cycle is especially advantageous if the heating element 110 is sensitive to rapid power increases, or if the heating element is designed for use with a 110V power source, but can also be used with a 240V power source even though the 240V source would otherwise provide too much power to the heating element too rapidly, were it not for the duty cycle. Typically, it is not necessary to use a duty cycle to cool down a heating element, i.e., the power is cut off during the entire cycle, although a duty cycle can be used to regulate or smooth cooling as well. An alternative to using duty cycle control is to use so called chopping.

[0080] Another aspect of the invention relates to the detection of the main power supply voltage, e.g., 110V, 240V, etc., and varying the duty cycle in dependence on the detected supply voltage. This is schematically illustrated in Figure 8, where the main supply voltage is typically 110V or 240V. A switch mode power supply circuit 800 determines the main voltage, e.g., using a variable frequency power supply in which the amplitude of the signal varies with voltage monitored by a peak detector 802. In other embodiments, the voltage can be determined using other techniques, e.g., a fixed frequency switch mode power supply. A signal indicative of the voltage of the main power supply will be sent to the ADC 804. Depending on the detected voltage, the duty cycle can be adjusted, e.g., a lower duty cycle will be selected if the voltage is high (e.g., 240V), and a higher duty cycle will be selected if the voltage is low (e.g., 120V). In variants, the duty cycle may also be varied within a low or high range to regulate the temperature of the heating element. The input voltage is regularly monitored and the

duty cycle is varied to compensate for fluctuations in the power supply. In this manner a substantially constant level of power is supplied to the heating element and the heating element is prevented from over heating. This control system provides a substantially consistent humidity level.

[0081] The voltage detection system may also be used to detect when the water tub is substantially empty and provide an indication to the user or turn of the humidifier. A substantially empty water tub may be detected by measuring the rate of increase in the temperature of the hot plate. When the tub is substantially empty the temperature will increase rapidly.

[0082] In another aspect, the determination of voltage can be used to disable the CPAP device and/or provide a warning to the user. For example, if the peak detector determines that the detected voltage (e.g., 240V), is different than the voltage for which the CPAP device was designed (e.g., 110V), then the microprocessor can disable the CPAP device and/or provide a signal to the user, e.g., "main power supply voltage not suitable for use with this device – see retailer."

[0083] Another algorithm for controlling the temperature of the humidifier is shown in Fig. 11. In step 1102, a determination is made as to whether T_H is within a predetermined temperature target range (T_R), which may be 5 or 10 degrees in range. If "yes", a signal is provided to turn off (or keep off) the power to the humidifier heating element (Step 1104). If "no" in step 1102, a determination is made in step 1106 whether $T_H > T_{MAX}$. If "yes", then the power to the humidifier heating element is cut off (Step 1104). If "no", then T_H must be less than T_{MIN} (Step 1108 can be thought of as confirmation that T_H is less than T_{MIN} if steps 1102 and 1106 indicate "no") and a signal is sent to turn on or keep on the power to the humidifier heating element (step 1110). As described above, the duty cycle or slew rate may be employed in which only for a fraction of the cycle time is the power actually supplied to the humidifier heating element. If "no", the program progresses to Step 1104.

[0084] In the embodiments of Figs. 10 and 11, control of the humidifier is carried out using program code which is programmed directly into the flow generator's

microprocessor, thereby avoiding the need for an integrated circuit or other hardware in the humidifier. The thermistor 115 in the humidifier may provide its temperature reading in terms of a voltage difference which can be converted by an analog to digital converter (ADC) to a signal which is useable by the microprocessor. When the microprocessor of the flow generator provides a signal to the humidifier to turn the power "on" or "off" to the heating element, the digital signal from the microprocessor may be converted to an analog signal and applied to the humidifier.

[0085] Fig. 12 is a schematic diagram of the electrical components of a cradle according to an embodiment of the present invention. This can be used in conjunction with the embodiments of Figs. 10 or 11 or other control schemes as well. This schematic has common components compared to the schematic of Fig. 6, but additional electrical components have been schematically illustrated in Fig. 12.

[0086] In the example of Fig. 12, the cradle circuit includes a thermistor component 200 and a heating element component 205 which are electrically coupled to a first TRIAC 210 such as an opto-coupled trigger TRIAC and a second preferably low cost TRIAC 215. A TRIAC is a three-terminal semiconductor that controls current in either direction. In general, the first TRIAC 210 provides electrical insulation between the CPU and the main power supply 211. The second TRIAC is a switch for applying current to the heating element 205. In another embodiment, the circuit may include two low cost TRIACs 210, 215.

[0087] The thermistor includes two leads 220, 225, one temperature signal lead 220 leads to an ADC which input is provided to the flow generator (CPU). The other lead 225 is provided to the ground (0 volts) connection of the first TRIAC 210. The two leads 230, 235 of the heating element 205 are coupled to the second TRIAC 215, which in this embodiment has two switches 240, 245, each of which is coupled to the AC main power supply 211. The first TRIAC 210 is also coupled to the AC main power supply 211. The first TRIAC controls the switching cycle of the second TRIAC 215 through command line 250.

[0088] The first TRIAC 210 includes a ("0" volt) ground 255 and a TTL (I/O) line 260 from the flow generator (CPU). The transistor-transiter-logic (TTL) line conveys switching commands from the microprocessor to the first TRIAC 210. One of the leads (e.g., line 265) from the AC main power supply 211 is configured to supply a signal that detects the zero crossing voltage as the AC power cycles through positive and negative voltages. Zero crossing triggering only allows the TRIAC to switch on or off when the current is zero, thus after a complete AC waveform has occurred. At the zero crossing points, the power is zero and there is no EMC or electrical power noise problem and current surges are eliminated. Accordingly, switching the second TRIAC 215 only at a zero crossing points reduces the risk of power surges and power noise from affecting the electronic circuits in the humidifier and control circuits.

[0089] The temperature of the water in the humidifier is determined using a transducer, such as a thermistor 200. The resistance of the thermistor is inversely proportional to the temperature of the thermistor. Thus, at high temperature the thermistor has a low resistance and at low temperatures the thermistor has a high resistance. The resistance of the thermistor determines the voltage applied to the temperature signal lead 220 that is sensed by the ADC of the microprocessor. Accordingly, the voltage signal from the thermistor indicates to the microprocessor the temperature of the water in the humidifier.

[0090] The humidifier control program, executed by the microprocessor and shown in Fig. 10 is a more preferred embodiment since it requires less program code and less memory to implement in the microprocessor. However, the humidifier control program embodiment of Fig. 11 may be more power efficient since the temperature need not reach T_{MAX} before the power to the humidifier is cut off. Further, the embodiment of Figure 11 may be more stable.

[0091] 4.3.2 Detection of Humidifier Fault Conditions From Temperature Signal

[0092] In accordance with an aspect of the invention, the temperature sensor has a gamut of detectable values. Within the gamut are defined a number of ranges including a

valid operating range, a low range, and a high range. For example, with reference to Fig. 9, the normal operating range (T_{MIN} to T_{MAX}) for a humidifier is about is 5°C to 70°C. Signals outside the valid operating range are used to infer non-connection of the humidifier or some other error condition, in which case power to the heating element is disconnected.

[0093] One aspect of an algorithm is to check the availability (connection and/or operation) of the humidifier as shown in Figure 13. In Step 1302, power is supplied to the CPAP unit or blower. In Step 1304, the ADC (which is in electrical communication with the humidifier) is initialized. Power is not yet supplied to the heating element 205 of the humidifier. The voltage signal 220 from the humidifier thermistor (an analog signal) is converted by the ADC into a digital value based on the voltage. The analog voltage signal 220 may be converted to one of 255 digital values that are available for an 8-bit digital signal (from an available 10-bit) from the ADC. It is noted that a different number of bits may be used and will consequently generate a different digital value. The digital value outputted by the ADC is indicative of the heater plate temperature in the humidifier, when the humidifier is connected and operating properly to heat water. There is a normal operating range (H_R) of ADC signals that result from normal operation of the humidifier. The ADC signal should be in normal operating range regardless of whether the heating element is on or off. ADC signals out of the normal operating range (H_R) may be used by the microprocessor to detect a disconnection of the humidifier or other potential problem.

[0094] The digital value is applied to the microprocessor in step 1306. Initially, the microprocessor determines if humidifier is attached and operational by determining whether the digital value from the ADC is within the possible operating range (H_R) of the humidifier (Step 1308). The ADC signal will be outside the operating range if the humidifier is not properly electrically connected to the control circuits in the blower/CPAP or the humidifier thermistor is not properly operating. If the microprocessor detects that the ADC signal is within the operating range (H_R) of the humidifier, the processor turns on the TTL I/O pin connected to line 260 and generates a

humidifier available signal for the LCD to indicate that the humidifier is attached and operational (Step 1310). The humidifier available signal may cause the display, e.g., LCD or LED, on the CPAP device (cradle, flow generator or humidifier), to glow or otherwise show that the humidifier is available and operating. The humidifier available signal can be an audible signal as well.

[0095] If the output of the ADC is not within the operating range (H_R) of the humidifier, a signal is generated that the humidifier is not available (Step 1312). An ADC output outside the operating range may result from a number of different conditions including but not limited to no humidifier attached, ambient conditions outside working range, humidifier fault. In Step 1314, the power to the humidifier is turned off by commanding (TTL 260) the first TRIAC 210 to switch off the second TRIAC 215 that disconnects the heating element from the main power 211, whereupon the humidifier and its connection can be manually checked. The signaling step (1312) may include a "warning" message presented on the display of the CPAP, and this message may be displayed after the power is turned off in step 1314, or steps 1312 and 1314 can be performed simultaneously.

[0096] There may also be another branch to this control system that continually detects for valid operation of the humidifier, while the humidifier is heating water for air flowing from the blower. The system detects abnormal conditions such as shorting to ground of the thermistor, humidifier incorrectly plugged in, or the presence of some other device plugged in. Under these circumstances the thermistor analog signal to the ADC will cause the ADC to generate a digital value that is outside the H_R. Upon receiving this out-of-H_R range digital value, the microprocessor will determine that a problem has occurred and consequently display a warning message and turn off power to the humidifier 1314. Further, the microprocessor may only determine that a problem has occurred after the out-of-H_R range digital value has persisted for some predetermined period, e.g., one second or one minute periods.

[0097] Fig. 13 represents a temperature based control loop to detect whether the humidifier is available. In this example, the thermistor resistance is used as an indicator

as to whether the humidifier is connected and/or operational. This can be implemented using software (e.g., with a program as shown in Fig. 13), where the ADC signal is based on the monitoring of thermistor resistance which is typically used to determine the temperature of the water in the humidifier (see Step 1306 in Fig. 13). When the control loop is using the thermistor-ADC signal as an indication of the availability of the humidifier, the microprocessor may read a zero (0) volt reading from the ADC as corresponding to a short circuit in the humidifier and determine that a poor connection or some other error exists in the humidifier. In the converse, if the microprocessor reads the thermistor-ADC signal at five (5) volts (which corresponds to an open circuit -- infinite resistance), the processor may interpret this 5-volt signal is indicating either no humidifier present or a poor connection between the humidifier and control circuit.A humidifier detection and control circuit operatively coupled to the flow generator CPU, as shown in Fig. 13.1, can also be provided. This circuit includes a thermistor (or other sensor) within the humidifier that is connected to a voltage divider comprising resistors R32, R41, R47 and R48. A voltage VCC is applied to one end of R32 and an analogue signal V_{ADC}, taken from the node between R41 and R48, is input to the ADC (analog-to-digital) portion of the CPU. The CPU outputs a heater high or heater low control signal out of the I/O port depending upon the resistance value of the thermistor. The circuit includes connections to a hardware protection circuit (not shown) which can cause the input to the ADC to go outside of certain limits (either high or low) based upon a fault occurrence, i.e., overheating, short circuit, etc., in the hardware.

[0098] V_{ADC} can be used for CPU to 1) read the heater element temperature, 2) detect attachment of a humidifier, 3) check if the attached humidifier is correct and/or 4) check if the attached humidifier has the correct connection. The example Table below calculates V_{ADC} verses thermistor resistance (related to the temperature). Fig. 13.2 is a graph illustrating values that can be utilized by the microprocessor software as an indication of the operation state and/or presence of the humidifier.

VCC V	VADC V	Rt (K Ohm)	R32 (K Ohm)	R41 (K Ohm)	R47 (K Ohm)	R48 (K Ohm)
5	1.454869359	10	18	27	47	100

4.3.3 Pull-Up Resistor

[0099] The availability of the humidifier can be detected using a pull-up resistor, as illustrated in Figs. 14 and 15. The pull-up resistor 1401 may be included in the control circuitry in the blower and may be between a voltage supply, e.g., five volts, and an input to the ADC. In this embodiment, the thermistor 200 is represented by a second resistance 1402 and its voltage signal 220 (V_1) is applied to the ADC. The voltage signal (V_3) applied to the input of the ADC is converted by the ADC to a digital eight (8) bit signal. If the humidifier is not attached or otherwise is not drawing any power, the humidifier (1402) does not absorb any portion of the voltage and is an open circuit, and thus only the pull-up resistor absorbs voltage and V_2 become equal to the V_3 voltage applied to the ADC. The microprocessor may determine that a digital signal equivalent to V_3 is outside the H_R range and indicates the absence of an operational humidifier. In particular, if the analog voltage (V_3) is at the reference voltage level, e.g. 5V or 3.8V, it indicates that there is an open circuit in the thermistor and that the humidifier is not properly attached or not operating properly. In this circumstance, the ADC digital value corresponding to this V_3 voltage will be the maximum digital value, e.g., 255. Alternatively, if the thermistor resistance (1402) is zero (short circuit) it will pull V_3 to ground (zero volts) and apply a zero level to the ADC, which in turn will output an minimal digital signal, e.g., 1, to the microprocessor. In this case, it is inferred or determined that the humidifier is not available (not attached and/or operating). See Fig. 14.

[00100] If the humidifier is connected and operational, the voltage (V_3) supplied to the ADC will be less than the reference voltage from the pull-up resistor 1401 and more than zero because of the resistance of the properly connected and operating thermistor 1402.

[00101] 4.4 Liquid Crystal Display (LCD) Driving

[00102] The present system uses an LCD such as a four-digit seven-segment clock (see, e.g., Figs. 18.1-18.3) as the visual output for the user interface to the CPAP. Typically, an LCD display includes its own LCD driving IC, and all that is required for display is to send data to the LCD driving IC and it will display the data. However, in another embodiment of the present invention, a separate LCD driving IC is eliminated, and the display segments 1802 are driven directly from the TTL data Input/Output (I/O) pins (5 volts) on the flow generator CPU. Preferably, an inexpensive microchip (CPU) is used to drive both the motor and the LCD. An external CPU controls the LCD using multiplexing. To provide external multiplexing is difficult as specific timing and voltage requirements are necessary.

[00103] The LCD display is divided into four common domains 1801 (1, 2, 3, 4 in Figs. 18-1, 19 and 20), e.g., wherein each domain can generate an alphanumeric character. Each common domain is divided into eight character segments 1802, labeled A, B, C, D, E, F and G in Fig. 18-4. Other character segments are periods (DP1, DP2, DP3 in Fig. 18-1) and a colon (COL in Fig. 18-1). The segments for each common domain can together display any one of a selected alphanumeric character. The segments 1802 are switched on and off based on voltages (Va1, Vb1, Vc1 in Fig. 16) applied to the input pins of the LCD display which include common electrode pins (PINs 1 to 4 in Fig. 18-5) and segment electrode input pins (PINs 5 to 12). The four voltages (0V, 1V, 2V and 3V) and the common and segment input pins on the LCD display, to which these voltages may be selectively applied allows for a unique combination of voltages and pins for each alphanumeric character to be displayed. (see Figures 16-20). Figure 18-5 shows the PIN mapping for the electrodes in an LCD display, wherein PINs 1 to 4 correspond to the common electrodes (COM0, ... COM3) for each of the four common domains 1801, and PINs 5 to 12 correspond to the electrodes for the segments 1802. For example, PIN 5 connects to the segment electrodes for the B, C and G segments of the 4 common domain and for the DP2. Applying a voltage to PIN 5 in combination with a voltage applied to a selected one of the four common PINS 1-4, allows the CPU to drive a selected one of the 4B, 4C, 4G and DP1 segments in the display. The CPU commands for applying the

sequences of common and segment voltage levels (0V, 1V, 2V and 3V) to the common and segment electrodes, respectively, of the LCD display is generated by the CPU of the blower. These commands cause the LCD display to show the appropriate alphanumeric characters of the desired message, e.g., "OK" or "OFF".

[00104] Each alphanumeric character segment 1802 in an LCD display comprises a top-electrode and a bottom electrode, as shown in Figs. 18.1-20. This is also schematically illustrated in Fig. 21. In order that the alphanumeric character segment is switched on, there needs to be an appropriate electrical potential between the top and bottom electrodes. In a device in accordance with the present invention, a 3 V potential is recommended. Furthermore, the potential should be alternating each time the segment is switched on. That is, if the top electrode is positive 3 V with respect to the bottom electrode one time, the next time it needs to be negative 3 V with respect to the bottom electrode when it is turned on. Whilst each segment could be individually controlled by a pair of data pins, a more efficient way to control them is to use a system of multiplexing. In this way, fewer data pins are needed to control a given number of segments. Because the electrodes in a display have a capacitance, it is possible to switch them serially, rather than in parallel. The capacitance of the display will cause a segment 1802 to remain at an ON/OFF state for a short period after voltage is switched off to the electrodes for that segment.

[00105] Fig. 22 shows a voltage cycle for switching the segments in each domain o of a display. Serially switching the LCD data pins provides sufficiently fast switching to provide a character display that is visually perceived to be simultaneously turned on. The maximum refresh time for each segment is 4 milliseconds. Thus the process of displaying information on an LCD display is to follow a complex pattern of applications of alternating 3 V potentials to a the matrix of electrodes of the domains and their segments.

[00106] The LCD may have 1/3 biasing, a ¼ duty cycle, and an operating voltage of 3V. As there is a time delay for segment electrodes to reach the appropriate 3 V potential and there is a requirement of quick display responses the system uses biasing

(which is 1/3rd of the operating voltage). The segments are held at a 1 V bias potential until turned on by applying a 3 V potential. The transition from 1V to 3V is sufficiently fast for display purposes compared to the transition from 0V to 3V. For quick display responses, the display is maintained at 1V, thus requiring a switch between 1V and 3V (as opposed to a switch between 0V and 3V) to cause a display segment 1802 to switch ON/OFF.

[00107] The ¼ duty cycle refers to grouping the character segments 1802 into four groups, and only applying full voltage to one group at a time and then moving to the next group. For example, the grouping may be: Group 1 - character segments corresponding to common electrode COM0, e.g., 4B, 4A, 3B, 3A, 2B, 2A, 1B and 1A, in the pin array shown in Fig. 18-5; Group 2 – character segments corresponding to common electrode COM1; Group 3 – character segments corresponding to common electrode COM2, and Group 4 – character segments corresponding to common electrode COM3. The common and segment electrodes for each group are powered together for ¼ of the duty cycle. Each group is powered sequentially in the duty cycle. Of course, whether power is supplied to a particular segment also depends on whether the CPU has determined that the segment is to be ON/OFF. Nevertheless, when the CPU has determined that power is to be applied to the common and segment electrodes of a particular electrode, that power is applied only during that ¼ of the power duty cycle for the Group to which the electrode is assigned. In this way each character segment is powered during one-quarter (¼) of the driving time for the duty cycle.

[00108] As is shown in Figure 21, each electrode (common - V_1, segment - V_2) of a segment 1802 receives a voltage output command from two CPU I/O data pins (I/O A, B or I/O C, D). Thus one segment uses data from four data pins. The TTL logic signal from each pin is either 0 V or 5V. In order to drive an electrode of a character segment with the appropriate combinations of voltages, a pair of pins needs to provide potentials of 0V, 1V, 2V, and 3 V (see Figures 17 and 22). Hence an aspect of the invention is a simple and inexpensive circuit that converts two TTL CPU I/O pin outputs into potentials of 0V, 1V, 2V, and 3 V.

[00109] As is shown in the circuit shown in Figure 21, the voltage levels to be applied to the electrodes of the character segments are achieved by using a combination of three resistors 2101, 2102, 2103, for each electrode. The three resistors may have a resistance ratio of 1:2:1, e.g., 100K, 200K and 100K. Preferably, the resistances are in the range of 50K to 400K. The resistors are arranged as shown in Figs.16 or 21. Although preferred values of the resistors are indicated above, other values are also possible, e.g., less than 50K and/or greater than 400K. There may be an array of three resistors for each of the input pins [PIN01(COM03), PIN02(COM02) ..., PIN05(SEG01), ... PIN12(SEG08)] of the LCD. One of the resistors 2103 is grounded. The other two are connected to a power source at an I/O port of the CPU.

[00110] The resistors 2101, 2102 are each connected to a separate TTL I/O port of the CPU. In one embodiment, there may be a pair of CPU I/O ports for each resistor, which would be 48 I/O ports in the case of a 12 pin LCD where each pin has two resistors 2101, 2102 connected to CUP I/O ports. To reduce the number of CPU I/O ports dedicated to driving the LCD, the higher value resistors 2102 can be collectively connected to a common CPU I/O port and each lower value resistor 2101 can be connected to a separate I/O port. In a third embodiment, the lower value resistors 2102 for the common electrode LCD pins (COM00 ... COM03) are collectively connected to a common CPU I/O port (LCD_C) and, similarly, the lower value resistors 2102 for the segment electrodes (SEG01 .... SEG08) are collectively connected to a common CPU I/O port (LCD_S).

[00111] 4.5 Detection of Motor Fault Conditions

[00112] The microprocessor of the flow generator can also be used to detect fault conditions in the blower motor. Fig. 23 schematically illustrates the general architecture, which includes a User Interface, for example, a keypad, and an LCD. The LCD provides information to the user or clinician such as the total time that the flow generator is ON and set pressure. In conjunction with the keypad and LCD, the patient can set ramp times (as defined within the limits set by the clinician). Embedded software is designed to

control the motor speed to produce a pressure as set by the clinician and the software may calculate one or more parameters relating to compliance, e.g., usage hours.

[00113] The CPU has a built in motor control functional block that provides the power stage driving signals with PWM control, hall sensor input for commutation control, a software configurable over RPM protection function, and/or motor stall detection function. In addition, the motor RPM may be detected by external hardware and a pull down signal is fed to the CPU as an emergency stop input to stop the motor if the motor RPM exceeds a predefined limit. Software would take appropriate action based on the input, e.g., disable motor, warn patient, vary motor speed, etc. If the motor is running in current mode, the motor current signal can serve as feedback to the CPU motor controller block for real time control. Also the motor current signal (represented by voltage on an ADC input pin) may be provided to the CPU for software to read if system requires detection of semi failing motor.

[00114] To gain the best accuracy of motor RPM detection for tolerating the variations on mechanical parameters, working conditions and manufacture tolerances, a full digital motor RPM detection circuit is designed to satisfy the demand. In comparison to the analogue F-V converter approach, one or more of the following advantages can be realized: lower cost; improved accuracy (e.g., no costly timing capacitors that has only 1% tolerance. The accuracy is defined by crystal at PPM level; excellent manufacturability (performance is define by design not manufacture process); multiple suppliers of parts ; stable under wide range of operation conditions; configurable to set any required RPM limit.

[00115] The flow generator may include a motor speed detection circuit for over RPM protection. As an independent electronic unit (independent of the PCB), the digital circuit provides motor speed detection functions for flow generator control. Also it offers high definition and configurable speed limiting levels.

[00116] An example circuit is shown in Fig. 24. The function of the circuit is to monitor motor sensor output, e.g., from a Hall sensor, optical sensor, etc., accumulate the output (e.g., pulses) over a predetermined amount of time using a clock, and decode these

inputs to establish a preset binary code to determine the motor speed level. Generally, the circuit includes three parts: clock timer, counter unit and binary decoder.

[00117] In this example, the clock timer uses a 32.768KHz crystal and *4060IC --- a 14 stage binary counter to generate the motor pulse count time base. The 32.768KHz crystal frequency output, after 14 divisions, establishes a count frequency down to 2Hz, and this frequency is utilized for the motor speed counting time base.

[00118] The counter unit is a resetable multi-stage binary counter, and it counts motor Hall sensor output (pulses) and outputs binary code. The output binary code is increment by each motor pulse as a ripple count, and the count is reset at a fixed time frame (e.g., 2Hz for this example). The binary decoder is a detector to detect the set binary code. Once the motor pulse counts reach to set binary number within the clock time, it will raise the flag.

[00119] The following is an example for calculation of a pre-set binary code. To obtain the binary number for motor speed limit, the maximum pulse rate per each clock cycle is calculated:

Set pulse number = (motor rpm x number of poles/60)/ clock frequency

[00120] This result (number) is converted into binary code. As a result, each binary digit represents an output of an IC pin Q1, Q2, Q3...Qn.

[00121] For example, 380 Dec= 101111100 bin.

[00122] As ... 1 0 1 1 1 1 1 0 0...

[00123] Q9 Q8 Q7 Q6 Q5 Q4 Q3 Q2 Q1

[00124] By connecting all the 1 digits to the logic AND decoder input, the output '1' is obtained when the output counter meets this code.

[00125] This system has the accuracy mainly depending on number of motor pulse per clock time base. For the clock it is based on 32.768KHz crystal at +/-100ppm –10 to 70°C. For example, if clock time base is set to 0.5s, the tolerance =0.5x0.0001=± 0.00005s. The clock tolerance is much greater than motor pulse frequency (0.0013s at 28Krpm) so it can only cause ±1 motor pulse error, (for 4 poles motor it has 2 pulses per turn therefore only ±0.5 turns per clock time base).

$$\text{Total accuracy} = \frac{\text{motor pulsing time per clock time base} \pm 1 \text{pulse time}}{\text{clock time base}}$$

[00126] This formula is true only when motor speed is at the set speed point. If motor speed is over the speed limits, it will trip out when the motor's pulse count reaches the set value before the clock resets the counter. The motor speed sensor can be associated with a look up table, as shown in Fig. 23.

[00127] In addition or in the alternative, a temperature monitor may be provided, e.g., in the flow generator. For example, a thermistor may be mounted on the flow generator PCB near the CPU that is on top of motor housing that provide the monitoring signal for CPU to identify the over temperature condition on main PCB directly and the motor indirectly. The temperature signal is converted to a voltage for CPU to read using an ADC channel.

[00128] While the invention has been described in connection with what are presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the invention. For example in an alternative embodiment the humidifier may be detected using a pull-down resistor instead of a pull-up resistor.

[00129] Also, the various embodiments described above may be implemented in conjunction with other embodiments, e.g., aspects of one embodiment may be combined with aspects of another embodiment to realize yet other embodiments. Further, each component or feature of each embodiment alone may constitute an additional embodiment. In addition, while the invention has particular application to patients who suffer from OSA, it is to be appreciated that patients who suffer from other illnesses (e.g., congestive heart failure, diabetes, morbid obesity, stroke, barriatric surgery, etc.) can derive benefit from the above teachings. Moreover, the above teachings have applicability with patients and non-patients alike in non-medical applications.

CLAIMS

1. A CPAP device wherein humidification control is performed by a microprocessor of the CPAP device without requiring a separate humidification control chip.

2. The CPAP device according to claim 1, wherein motor control and display control are performed by the microprocessor without requiring a separate motor control IC and display control IC.

3. A CPAP device comprising:

a flow generator including a microprocessor with an analog-to-digital converter (ADC);

a humidifier detachably coupled to the flow generator; and

a temperature sensor in communication with the humidifier and adapted to produce a voltage signal provided to the flow generator microprocessor via the ADC,

wherein the microprocessor is programmed with a humidifier control program to control power supply to the humidifier in accordance with output of the temperature sensor.

4. The CPAP device according to claim 3, wherein the humidifier control program includes machine readable code configured to:

compare the converted voltage signal of the humidifier temperature (T_H) to a maximum permissible temperature of the humidifier (T_{MAX});

turn off power to the humidifier if the temperature is greater than T_{MAX}; and

turn on or keep on the power to the humidifier if the temperature is not greater than T_{MAX}.

5. The CPAP device according to claim 4, wherein the comparison of T_H to T_{MAX} is periodically carried out upon expiration of a predetermined time period and, if T_H is not greater than T_{MAX}, power is provided to the humidifier for only a fraction of the predetermined time period.

6. The CPAP device according to claim 5, wherein the fraction is about 5-95% of the predetermined time period.

7. The CPAP device according to any one of claims 5-6, wherein the predetermined time period is in the range of about 1-10 seconds.

8. The CPAP device according to any one of claims 4-7, wherein the flow generator is in communication with a main power voltage detector, and the fraction is determined in accordance with the detected main power voltage.

9. The CPAP device according to any one of claims 1-8, wherein the microprocessor is configured to disable the CPAP device if a main power supply voltage is incompatible with the voltage rating of the CPAP device.

10. The CPAP device according to claim 3, wherein the humidifier control program includes machine readable code configured to:

compare the converted voltage signal of the humidifier temperature (T_H) to a temperature range (T_R), and

turn off or keep off power supply to the humidifier if T_H is within T_R.

11. The CPAP device according to claim 10, wherein, if T_H is not within T_R, the code is configured to:

turn off or keep off power supply to the humidifier if T_H is greater than a maximum allowable temperature (T_{MAX}), and if T_H is not greater than T_{MAX}, turn on or

keep on the humidifier if T_H is less than a minimum temperature (T_{MIN}) and turn off or keep off the power supply to the humidifier if T_H is not less than T_{MIN}.

12. The CPAP device according to any one of claims 1-11, wherein the microprocessor has a capacity of about 100-150 bytes.

13. The CPAP device according to any one of claims 3-12, wherein the humidifier control program includes machine readable code configured to determine whether the humidifier is available.

14. The CPAP device according to claim 13, wherein the microprocessor executes a humidifier control program to:

receive output from the ADC, and

signal whether the humidifier is available based on the ADC output.

15. The CPAP device according to claim 14, wherein a signal is generated to indicate that the humidifier is not available if the output from the ADC is not within the possible range of operability of the humidifier.

16. The CPAP device according to any one of claims 14-15, wherein a signal is generated to indicate that the humidifier is attached and operational if the output from the ADC is within the possible range of operability of the humidifier.

17. The CPAP device according to any one of claims 15-16, wherein the possible range of operability is between about 5°-70°C.

18. The CPAP device according to claim 13, further comprising a pull-up resistor in communication with the ADC, wherein the ADC provides a signal to the

microprocessor having a first value if the humidifier is not available and a second value, different from the first value, if the humidifier is connected and operable.

19. The CPAP device according to claim 18, wherein the microprocessor includes code to signal availability of the humidifier in accordance with the signal provided from the ADC to the microprocessor via the pull-up resistor.

20. The CPAP device according to any one of claims 18-19, wherein power is supplied to the humidifier, and if the converted voltage signal from the ADC to the microprocessor indicates power loss attributable only to the pull up resistor, then a signal is generated to indicate unavailability of the humidifier, and wherein if the converted voltage signal indicates power loss which is different from the power loss attributable only to the pull-up resistor, then a signal is generated to indicate availability of the humidifier.

21. The CPAP device according to any one of claims 3-20, further comprising a cradle to support the flow generator and the humidifier.

22. The CPAP device according to claim 21, wherein the cradle includes the temperature sensor and a heater plate with a heating element in communication with the humidifier, the temperature sensor being in thermal communication with the heating element.

23. The CPAP device according to any one of claims 3-22, wherein the temperature sensor comprises a thermistor.

24. The CPAP device according to any one of claims 3-23, wherein the flow generator includes main electrical components consisting essentially of the microprocessor, a motor, a power supply unit and a display.

25. The CPAP device according to any one of claims 3-24, wherein the microprocessor is programmed with machine readable code to control the motor and the display.

26. A method for controlling a humidifier of a CPAP device, comprising:

monitoring a temperature of the humidifier;

generating a voltage signal representative of the humidifier temperature;

converting the voltage signal to a digital signal;

applying the digital signal to a microprocessor of a flow generator of the CPAP device, and

supplying power to the humidifier in accordance with the digital signal.

27. The method according to claim 26, wherein the microprocessor includes a humidifier control program having machine readable code configured to:

compare the converted voltage signal of the humidifier temperature (T_H) to a maximum permissible temperature of the humidifier (T_{MAX});

turn off power to the humidifier if the temperature is greater than T_{MAX}; and

turn on or keep on the power to the humidifier if the temperature is not greater than T_{MAX}.

28. The method according to claim 27, further comprising periodically comparing T_H to T_{MAX} upon expiration of a predetermined time period and, if T_H is not greater than T_{MAX} , providing power to the humidifier for only a fraction of the predetermined time period.

29. The method according to claim 28, wherein the fraction is about 5-95% of the predetermined time period.

30. The method according to any one of claims 28-29, wherein the predetermined time period is about 1-10 seconds.

31. The method according to any one of claims 26-30, wherein the microprocessor has a capacity of about 100-150 bytes.

32. The method according to any one of claims 26-31, further comprising determining whether the humidifier is available.

33. The method according to claim 32, wherein the humidifier availability is determined by:

receiving output from the ADC, and

signaling whether the humidifier is available based on the ADC output.

34. The method according to claim 33, further comprising generating a signal to indicate that the humidifier is not available if the output from the ADC is not within the permissible range of operability of the humidifier.

35. The method according to any one of claims 33-34, further comprising generating a signal to indicate that the humidifier is attached and operational if the output from the ADC is within the permissible range of operability of the humidifier.

36. The method according to any one of claims 34-35, wherein the permissible range of operability is between about 5°-70°C.

37. The method according to any one of claims 26-36, further comprising providing the flow generator with a pull-up resistor.

38. The method according to claim 37, further comprising providing the microprocessor with code to signal availability of the humidifier in accordance with the signal provided to the microprocessor via the pull-up resistor.

39. The method according to claim 37, wherein power is supplied to the humidifier, and if the converted voltage signal supplied to the microprocessor indicates power loss attributable only to the pull-up resistor, then a signal is generated to indicate unavailability of the humidifier, and wherein if the converted voltage signal indicates a power loss which is different from the power loss attributable only to the pull-up resistor, then a signal is generated to indicate availability of the humidifier.

40. The method according to any one of claims 26-39, further comprising programming the microprocessor with machine readable code to control motor and display functions.

41. A method for controlling a humidifier of a CPAP device including a controller comprising:

controlling a heating element in the humidifier with command signals from the controller;

sensing a temperature of a fluid in the humidifier with a sensor in the humidifier that transmits signals to the controller;

establishing an acceptable operating range for the signal transmitted to the controller;

determining whether the transmitted signal is within the acceptable operating range;

if the signal is within the acceptable operating range treating the signal as being indicative of the temperature of the fluid in the humidifier and using the signal to control the heating element, and

if the signal is outside of the acceptable operating range, the controller determines the humidifier to be unavailable.

42. The method of claim 41 wherein the controller is separately housed from the humidifier and said method further comprises turning off a power to the humidifier if it is unavailable.

43. The method of claim 41 further comprising determining a target range for the signal which corresponds to an acceptable temperature range for the fluid, wherein the target range is within the acceptable operating range.

44. The method of claim 43 further comprising activating the heating element to heat the fluid when the signal is within the acceptable operating range and below the target range.

45. The method of claim 43 further comprising deactivating the heating element when the signal is within the acceptable operating range and above the target range.

46. A liquid crystal display (LCD) comprising:

a character domain including a plurality of segments, and

a control circuit to selectively energize one or more of the segments on a time share basis, at least two of the segments being driven serially.

47. The display of claim 46 wherein the LCD further comprises selectively energizing the segments based on a duty cycle.

48. The display of claim 47 wherein the duty cycle is divided into four periods and during each of said periods a different group of segments is driven.

49. The display of claim 46 further comprising a bias voltage applied to the segments.

50. The display of claim 46 further comprising a three resistors circuit having a current ratio of 1:2:1 to provide four different voltages to the segments.

51. The display of claim 50, wherein the four different voltages include 0, 1, 2 and 3 volts.

52. A controller and a liquid crystal display (LCD) for an electromechanical device comprising:

a control processor configured to control a plurality of functions in the device and one of said functions is driving the LCD;

said LCD having inputs receiving control signals from the control processor, wherein the LCD lacks a separate display driver processor;

a common domain in the LCD for displaying alphanumeric characters, wherein said common domain includes a plurality of segments and each segment is a liquid crystal sandwiched between a common electrode and a segment electrode, wherein said common electrode is electrically connected to the entire common domain and each segment has a corresponding unique segment electrode, and wherein said segment can be activated by applying voltages to the common electrode and segment electrode corresponding to the segment;

said common electrode having an input port on the LCD;

each of said segment electrodes having a corresponding input port on the LCD;

wherein the controller has a duty cycle for applying power to the common and segment electrodes for the segments, the controller applies power during the duty cycle sequentially to a first segment and then to a second segment.

53. The controller and a liquid crystal display (LCD) in claim 52 further comprising a plurality of common domains, each of which domains includes a unique common electrode.

54. The controller and a liquid crystal display (LCD) in claim 52 further comprising a voltage output lines from the controller connected to the input ports of the LCD for apply voltages to the common and segment electrodes.

55. The controller in claim 54 wherein the connection between the voltage output lines from the controller and the LCD ports comprises a first voltage output line connected to a first resistor in series with one of said LCD input ports, and a second voltage output line connected to a second resistor in series with said one of said common and segment electrodes, wherein the first resistor has a lower resistance value than the second resistor.

56. The controller of claim 55 wherein a unique voltage output line is connected to each first resistor and a single voltage output line is connected to a plurality of the second resistors.

57. A method for controlling a CPAP device set to operate at predetermined voltage comprising:

monitoring a main power supply voltage;

comparing the monitored voltage to the predetermined voltage; and

producing a control signal based on the comparison to control operation of the CPAP device.

58. The method of claim 57, wherein the control signal disables the CPAP device if the monitored voltage is not equal to the predetermined voltage, and the method includes providing a warning signal via the CPAP device.

59. The method of any one of claims 57-58, wherein the CPAP device includes a humidifier having a heating element that operates based on a duty cycle, wherein the method includes adjusting the duty cycle based on the comparison between the monitored voltage and the predetermined voltage.

60. A CPAP device comprising:

a flow generator including a microprocessor;

a motor provided to the said flow generator; and

a digital circuit to detect RPM of the motor, said digital circuit including a clock timer, a counter unit and a decoder, wherein the decoder is configured to generate a signal that is indicative of RPM as a function of time.

61. The CPAP device of claim 60, wherein the microprocessor is configured to compare the decoder signal to a predetermined value.

62 The CPAP device of any one of claims 60-61, wherein the microprocessor is configured to vary the RPM of the motor based on the decoder signal.

63. The CPAP device of any one of claims 60-62, further comprising a temperature sensor associated with a printed circuit board, the temperature sensor being configured to detect a temperature of the motor, said temperature signal being compared to a predetermined temperature and used to disable the motor in appropriate conditions.

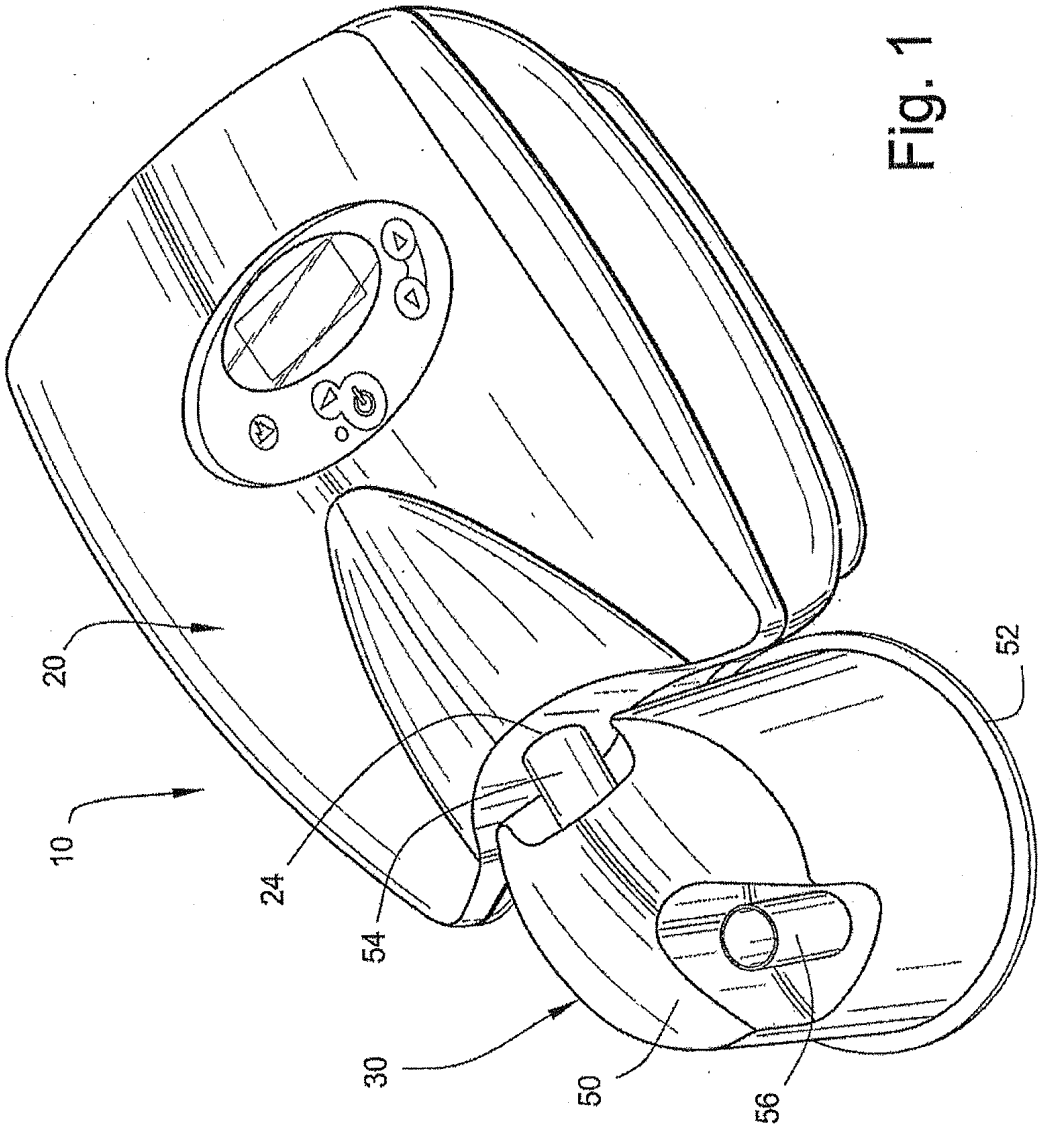


Fig. 1

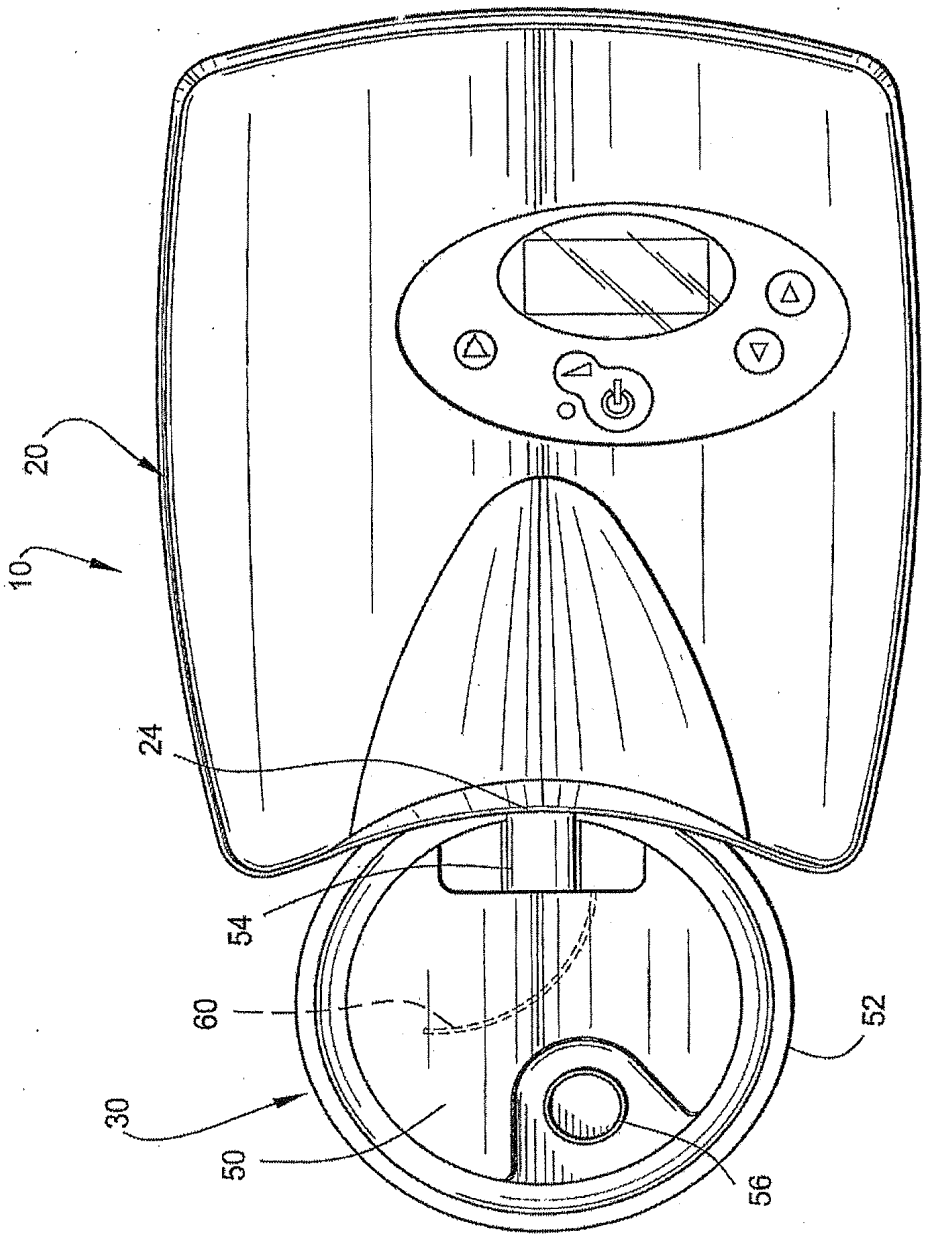


Fig. 2

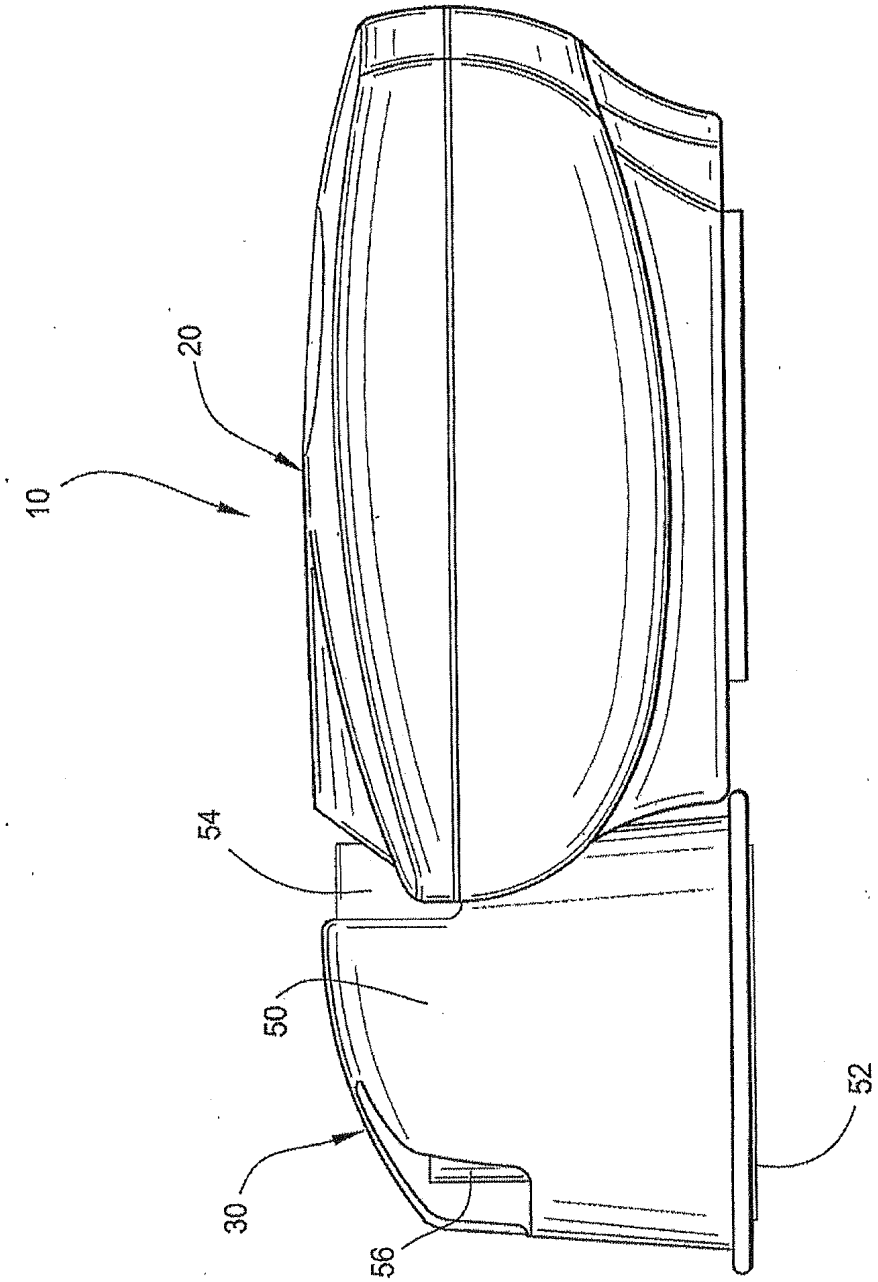


Fig. 3

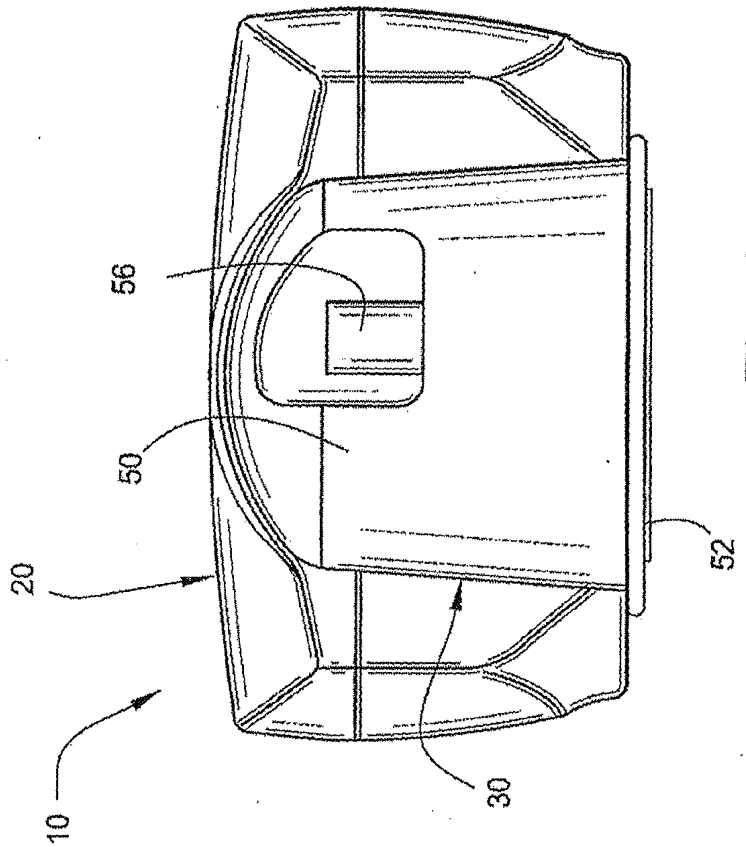


Fig. 4

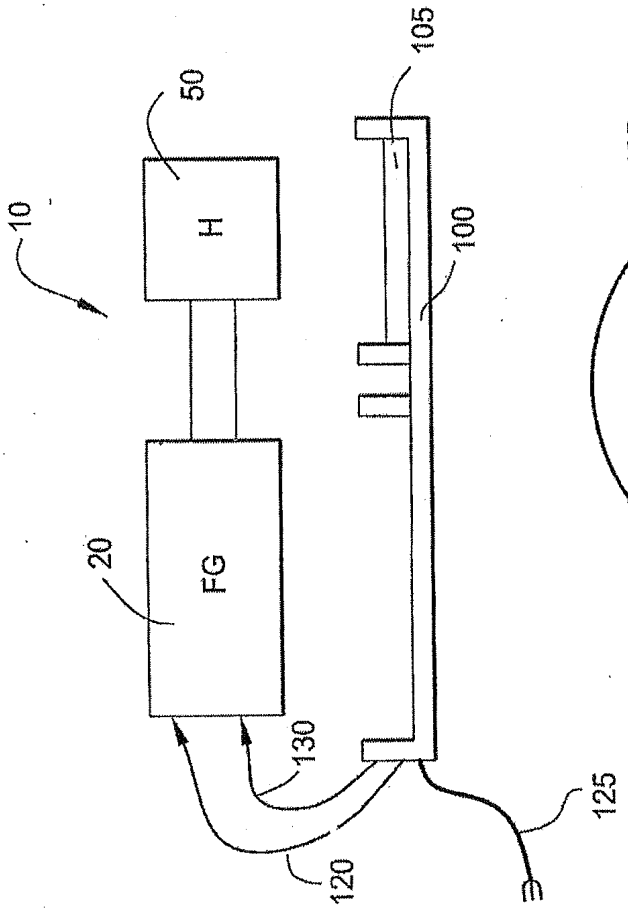


Fig. 5

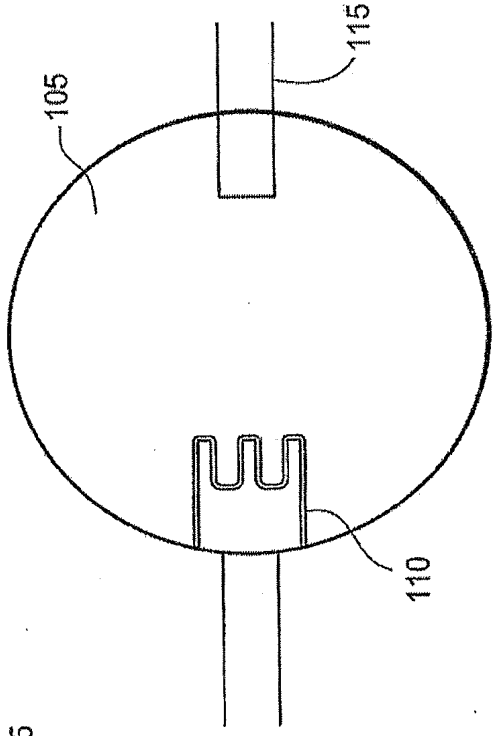


Fig. 6

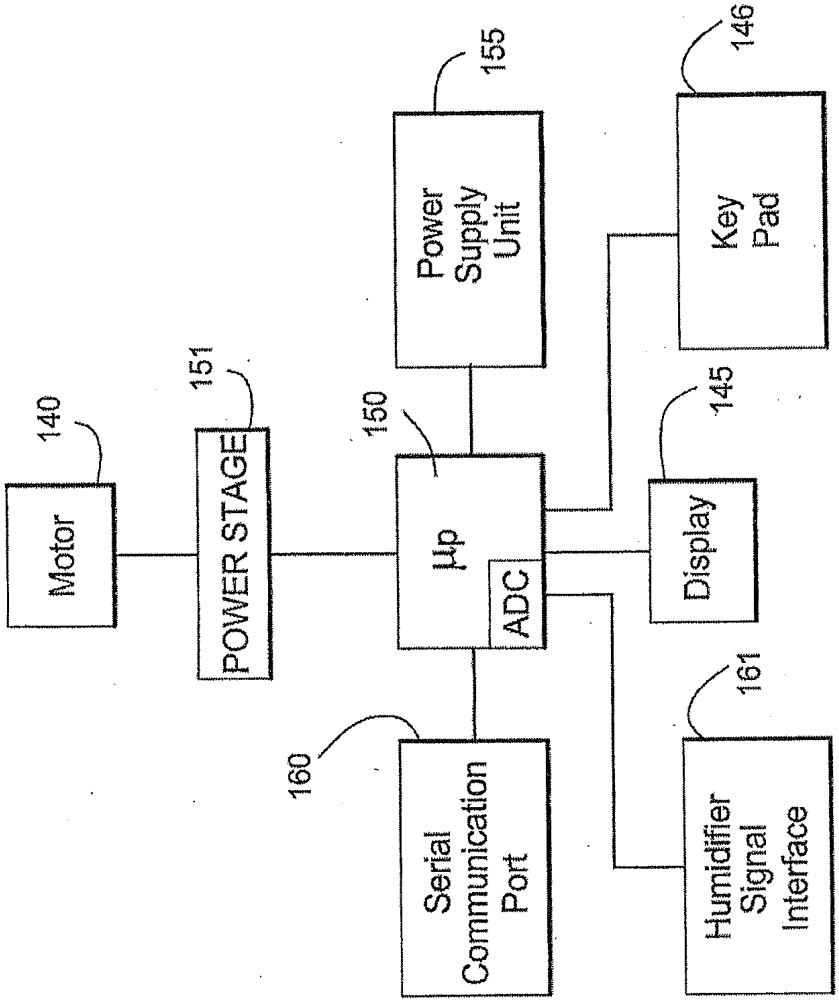

Motor
140
POWER STAGE
151
µp
ADC
150
Power Supply Unit
155
Key Pad
146
Display
145
Serial Communication Port
160
Humidifier Signal Interface
161

Fig. 7

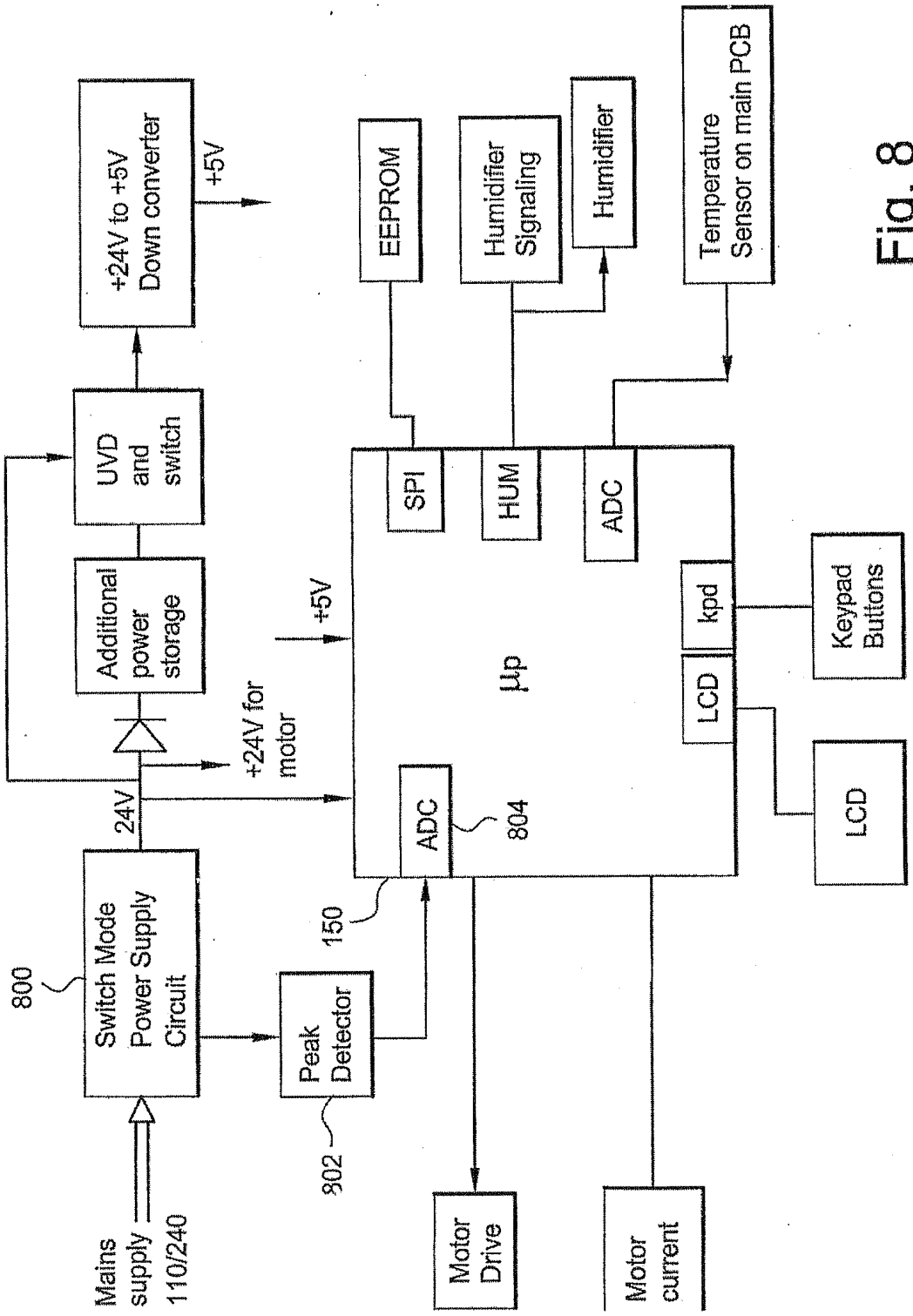

Mains supply 110/240
800
Switch Mode Power Supply Circuit
24V
Peak Detector
902
150
ADC
804
μp
SPI
HUM
ADC
+5V
+24V for motor
Additional power storage
UVD and switch
+24V to +5V Down converter
+5V
EEPROM
Humidifier Signaling
Humidifier
Temperature Sensor on main PCB
kpd
Keypad Buttons
LCD
LCD
Motor Drive
Motor current

Fig. 8

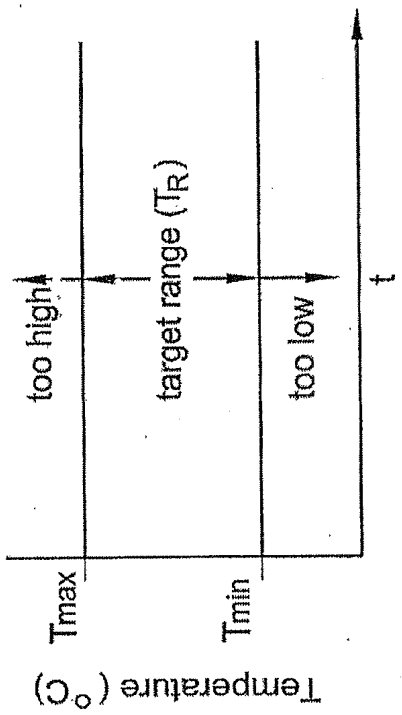


Fig.9

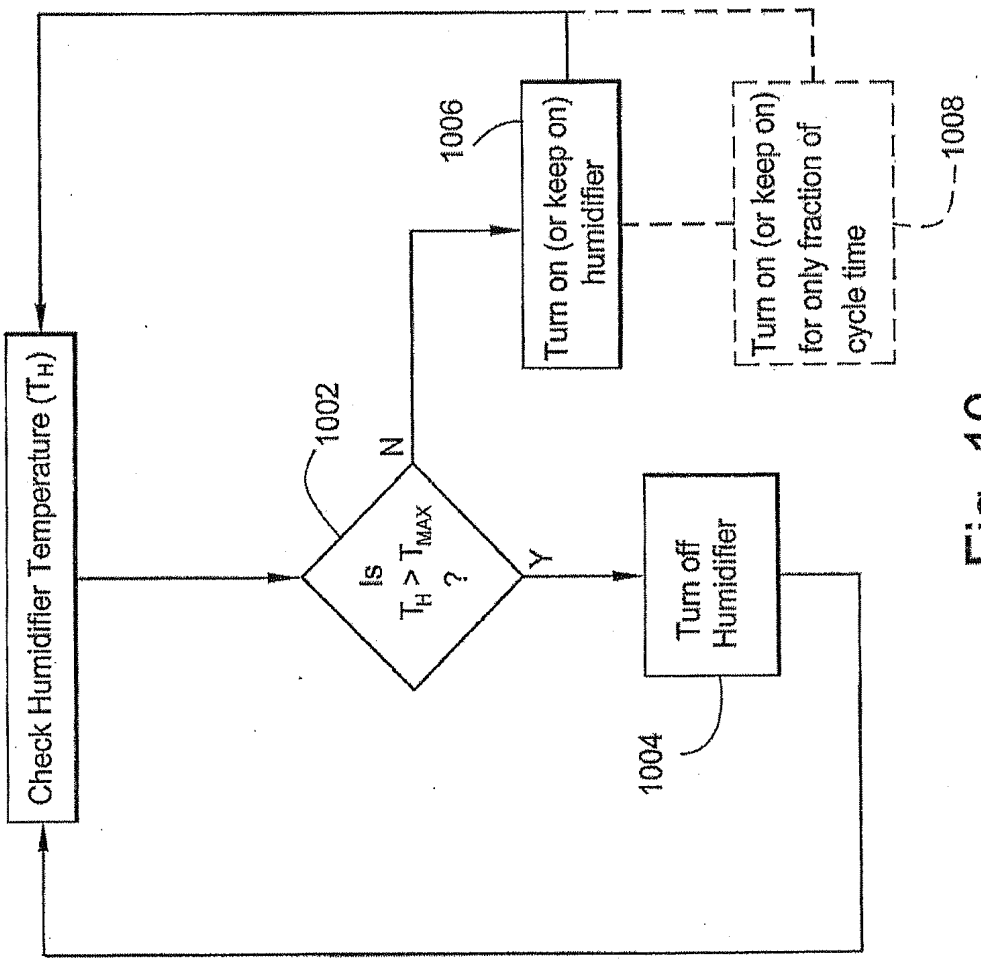

Check Humidifier Temperature (T_H)
1002
Is $T_H > T_{MAX}$?
N
Y
1006
Turn on (or keep on) humidifier
Turn on (or keep on) for only fraction of cycle time
1008
Turn off Humidifier
1004

Fig. 10

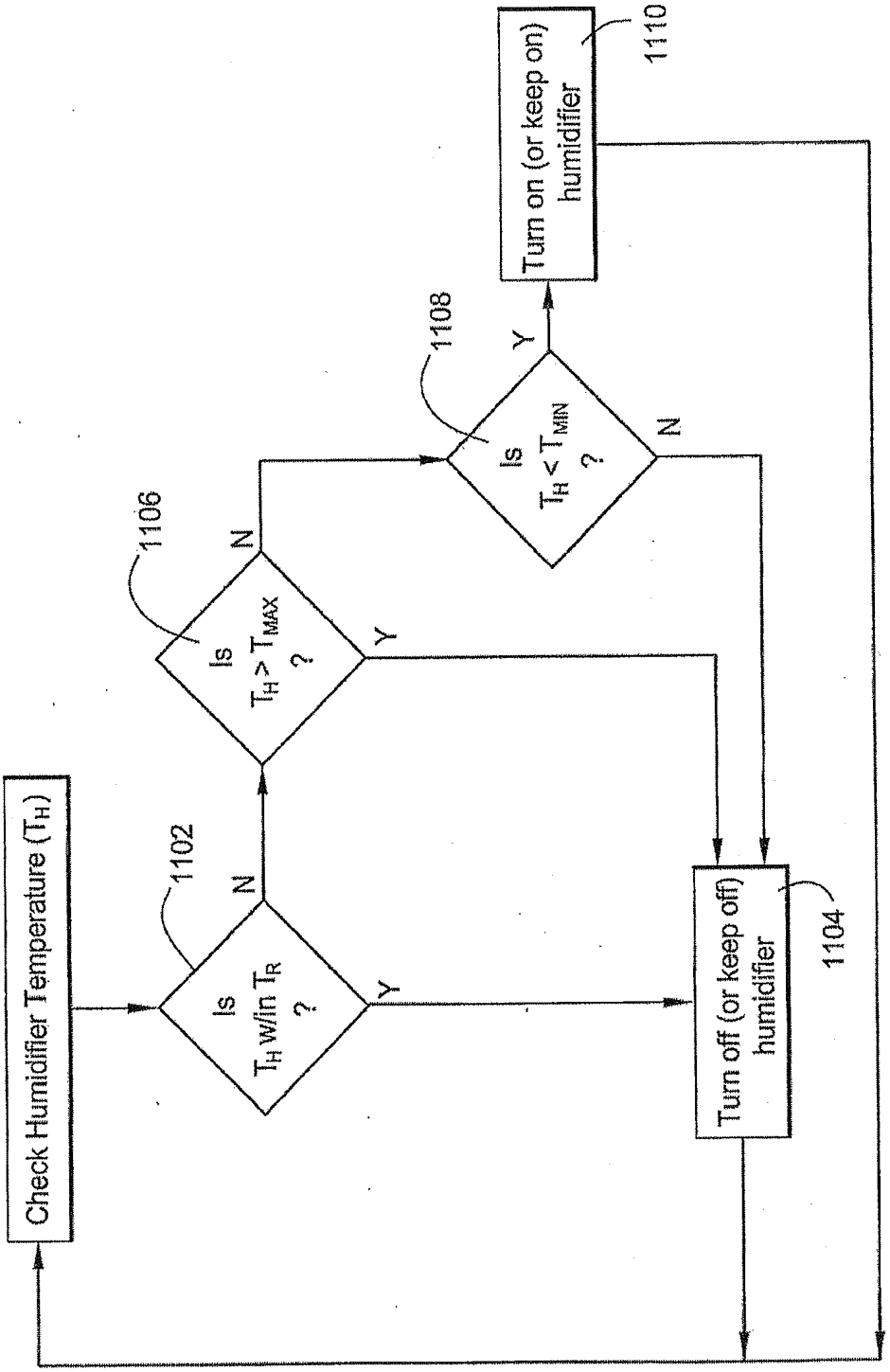

Check Humidifier Temperature (T_H)
Is T_H w/in T_R ?
1102
N
Y
Is $T_H > T_{MAX}$?
1106
N
Y
Is $T_H < T_{MIN}$?
1108
Y
N
Turn on (or keep on) humidifier
1110
Turn off (or keep off) humidifier
1104

Fig. 11

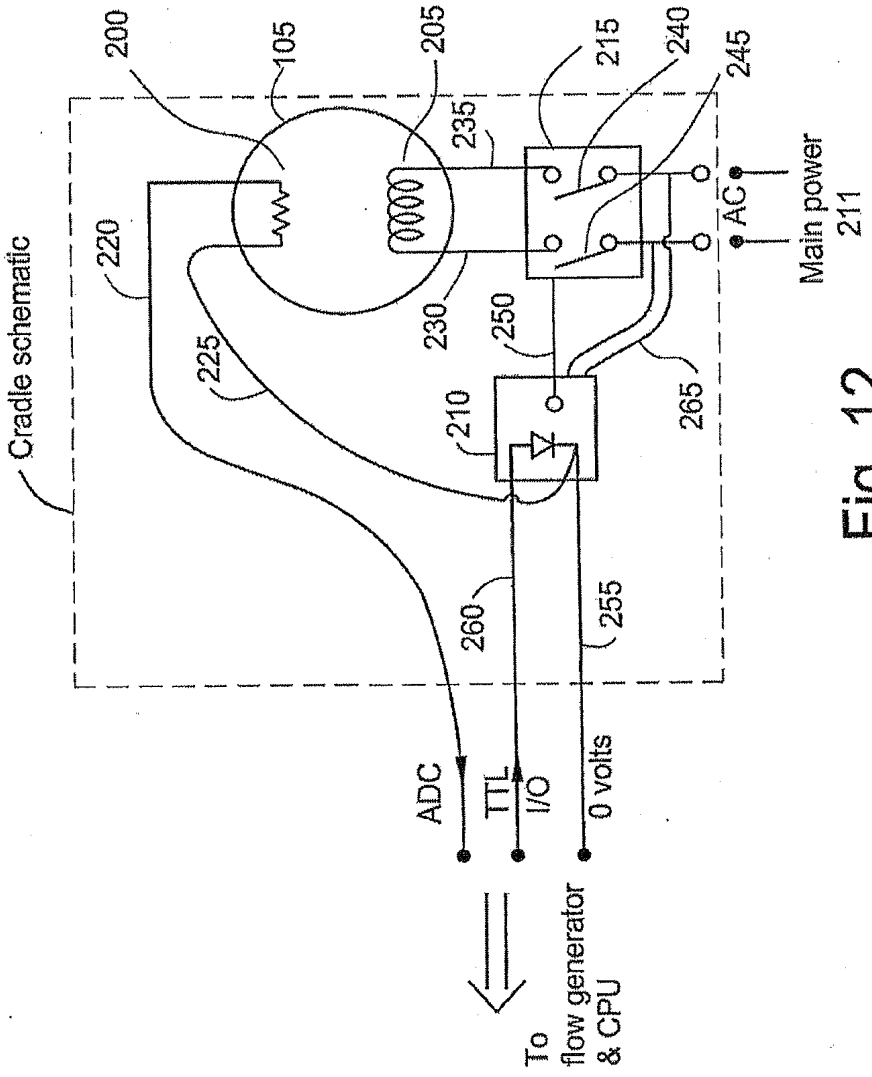

Cradle schematic
200
105
205
215
240
245
235
220
225
230
250
210
265
260
255
AC
Main power
211
ADC
TTL
I/O
0 volts
To
flow generator
& CPU

Fig. 12

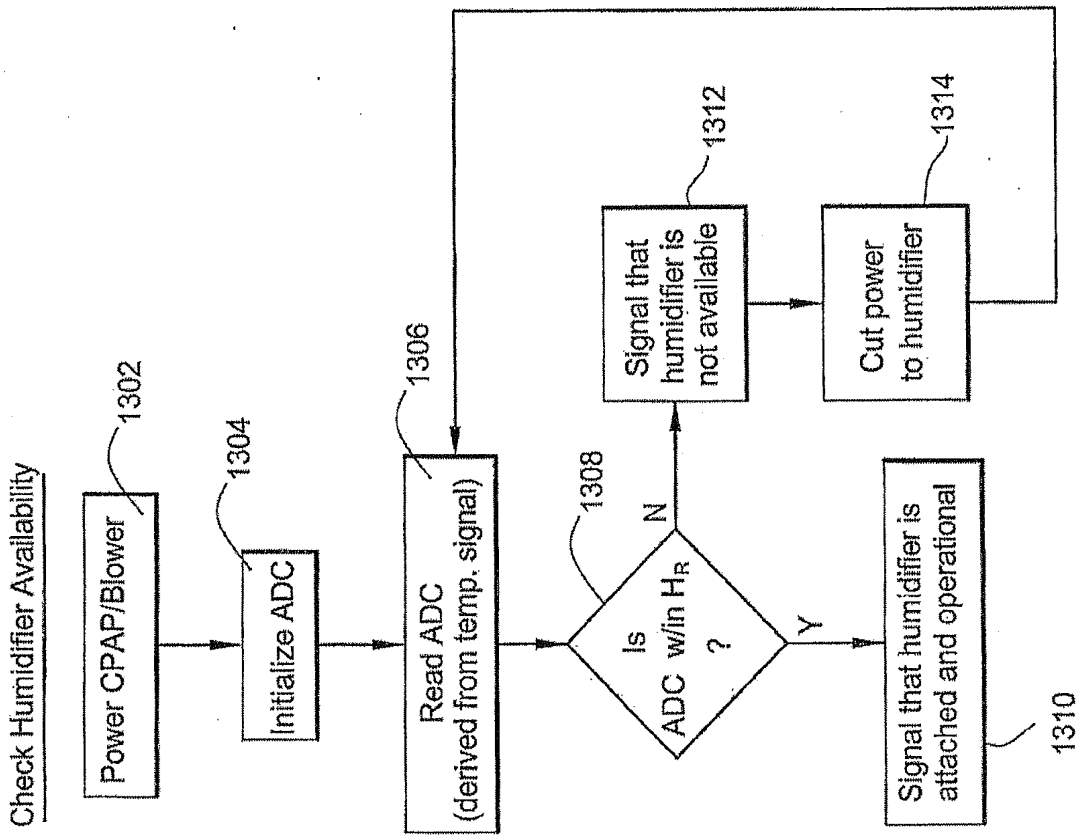

Check Humidifier Availability
Power CPAP/Blower
1302
Initialize ADC
1304
Read ADC (derived from temp. signal)
1306
Is ADC w/in H_R ?
1308
N
Y
Signal that humidifier is not available
1312
Cut power to humidifier
1314
Signal that humidifier is attached and operational
1310

Fig. 13

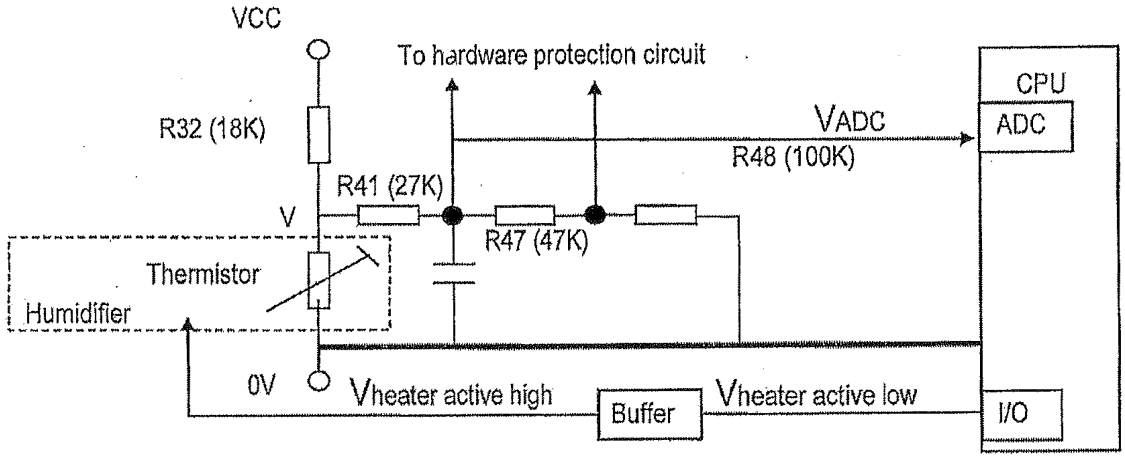


Fig. 13.1

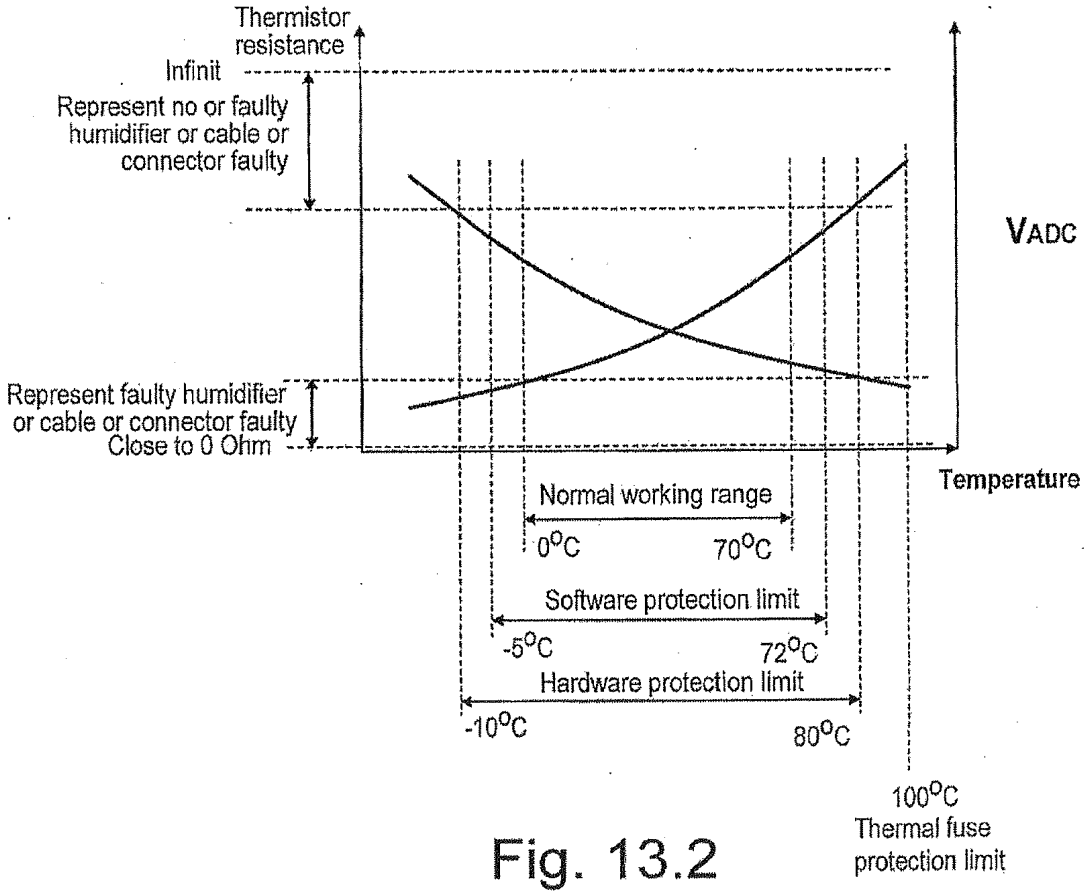


Fig. 13.2

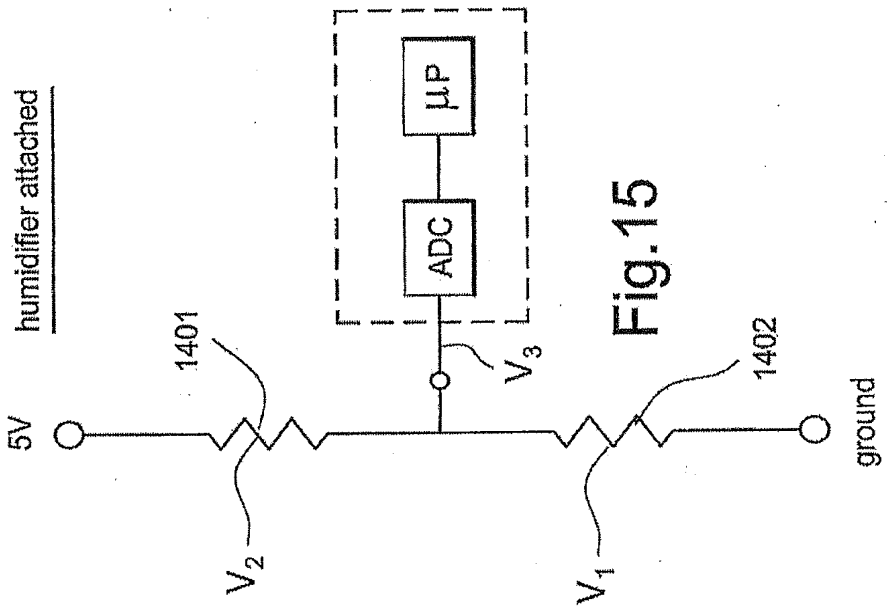

humidifier attached
5V
1401
V_2
ADC
µP
V_3
V_1
1402
ground

Fig.15

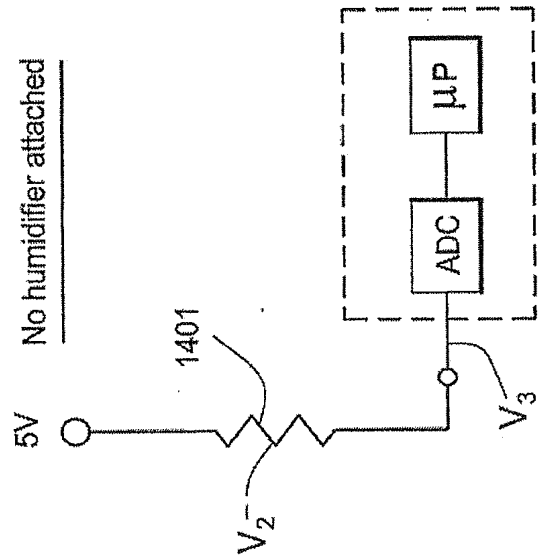

No humidifier attached
5V
1401
V_2
ADC
µP
V_3

Fig.14

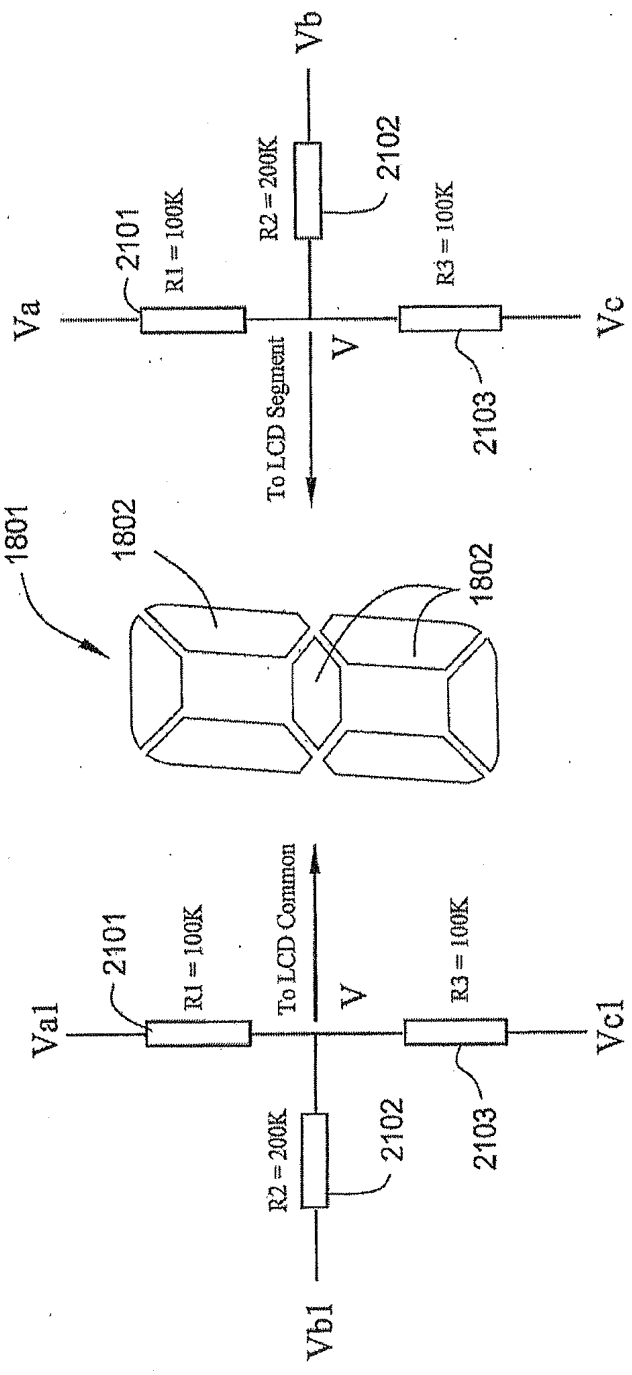

Va
2101
R1 = 100K
R2 = 200K
2102
Vb
R3 = 100K
Vc
V
To LCD Segment
2103
1801
1802
1802
Va1
2101
R1 = 100K
To LCD Common
V
R3 = 100K
Vc1
R2 = 200K
2102
2103
Vb1

Fig. 16

Va	Vb	Vc	V (reference to 0V)
0V	0V	0V	V1 = 0V
0V	5V	0V	V2 = 1V
5V	0V	0V	V3 = 2V
5V	5V	0V	V4 = 3V

Fig. 17

Fig. 18-2

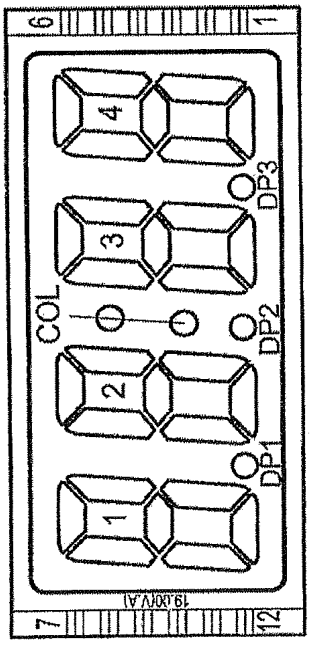
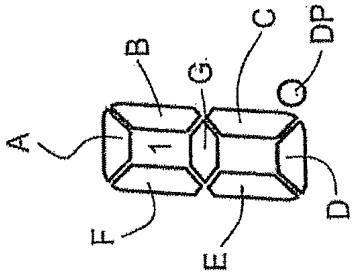


Fig. 18-1

Fig. 18-3

PIN	1	2	3	4	5	6	7	8	9	10	11	12
COM0				COM0	4B	4A	3B	3A	2B	2A	1B	1A
COM1				COM1	4G	4F	3G	3F	2G	2F	1G	1F
COM2				COM2	4C	4E	3C	3E	2C	2E	1C	1E
COM3	COM3				DP2	4D	DP3	3D	COL	2D	DP1	1D

Fig. 18-5



g. 18-4

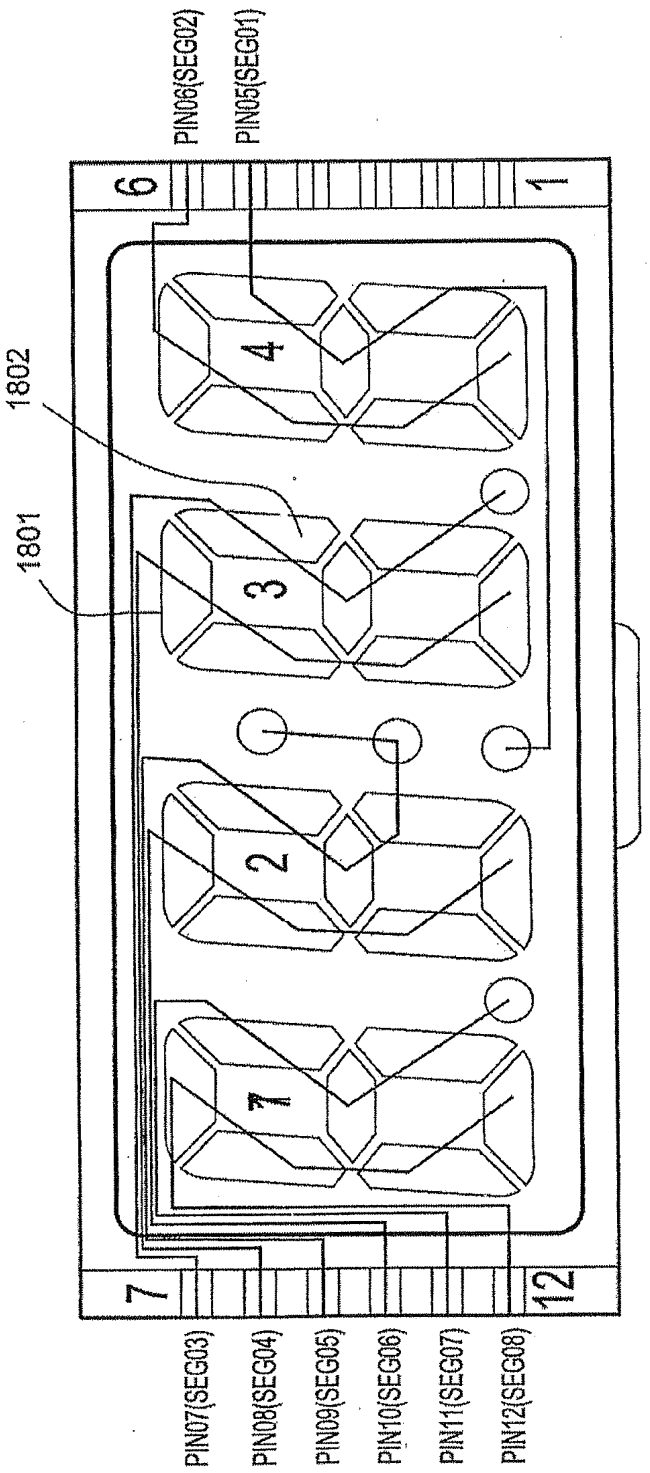

PIN06(SEG02)
PIN05(SEG01)
6
1
1802
1801
4
3
2
1
7
12
PIN07(SEG03)
PIN08(SEG04)
PIN09(SEG05)
PIN10(SEG06)
PIN11(SEG07)
PIN12(SEG08)

Fig.19

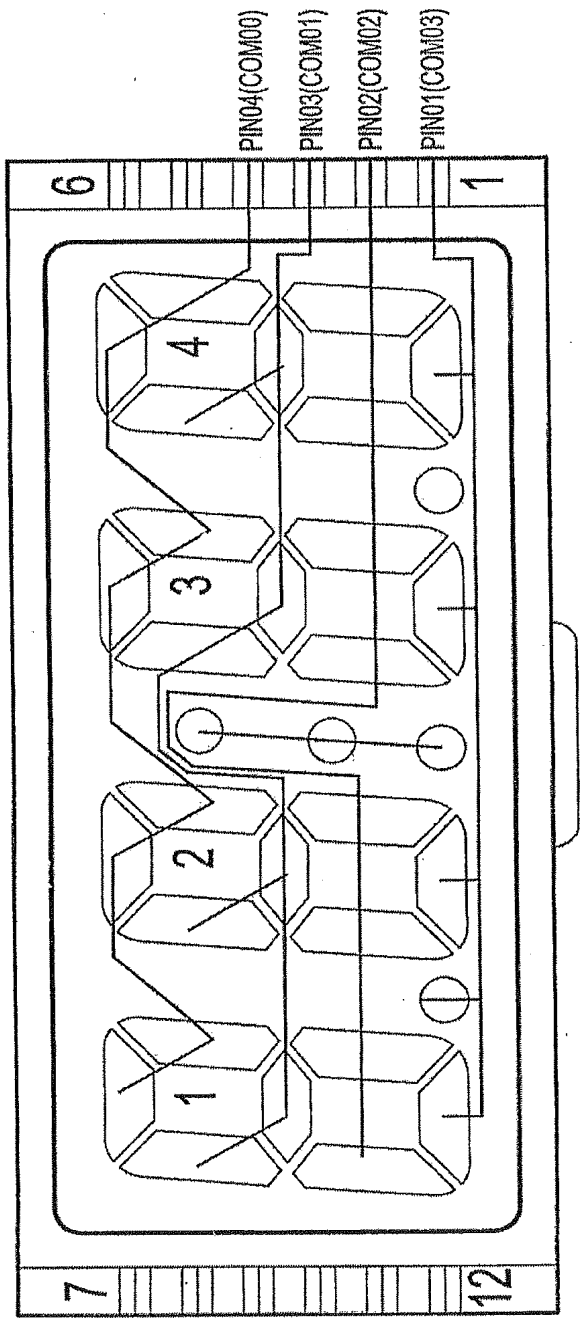


Fig.20

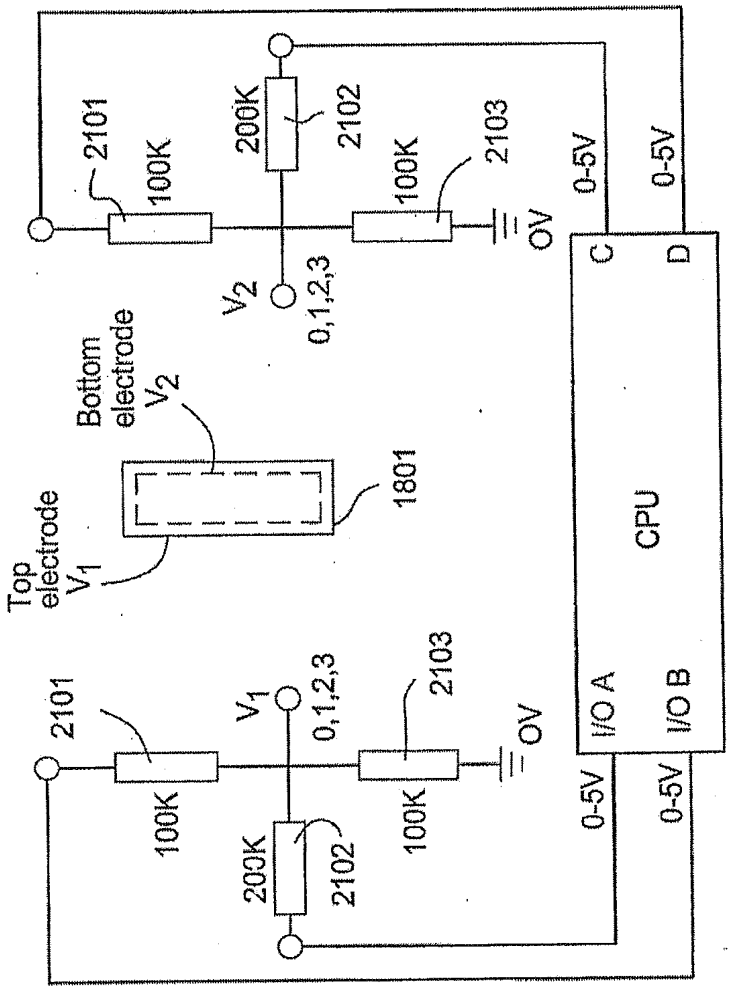

2101
100K
200K
2102
100K
2103
0V
0-5V
0-5V
V_2
0,1,2,3
Bottom electrode
V_2
1801
Top electrode
V_1
CPU
C
D
I/O A
I/O B
2101
V_1
0,1,2,3
2103
0V
100K
200K
2102
100K
0-5V
0-5V

Fig. 21

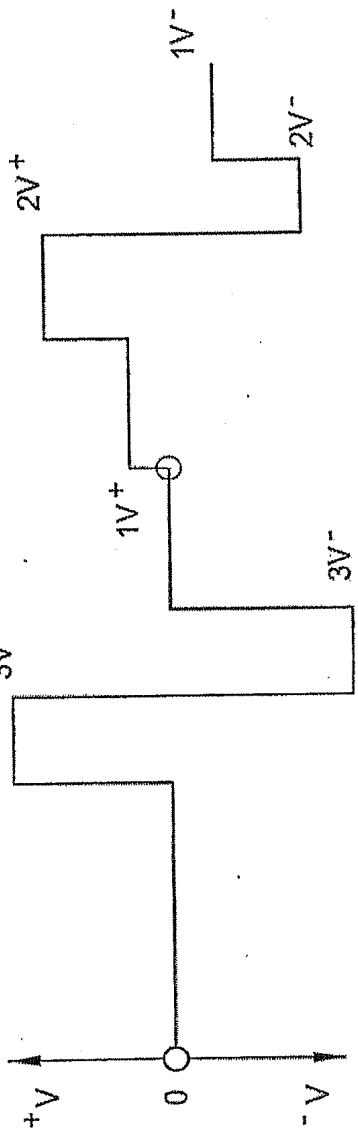

$1V^-$
$2V^-$
$2V^+$
$1V^+$
$3V^-$
$3V^+$
+V
0
-V

Fig. 22

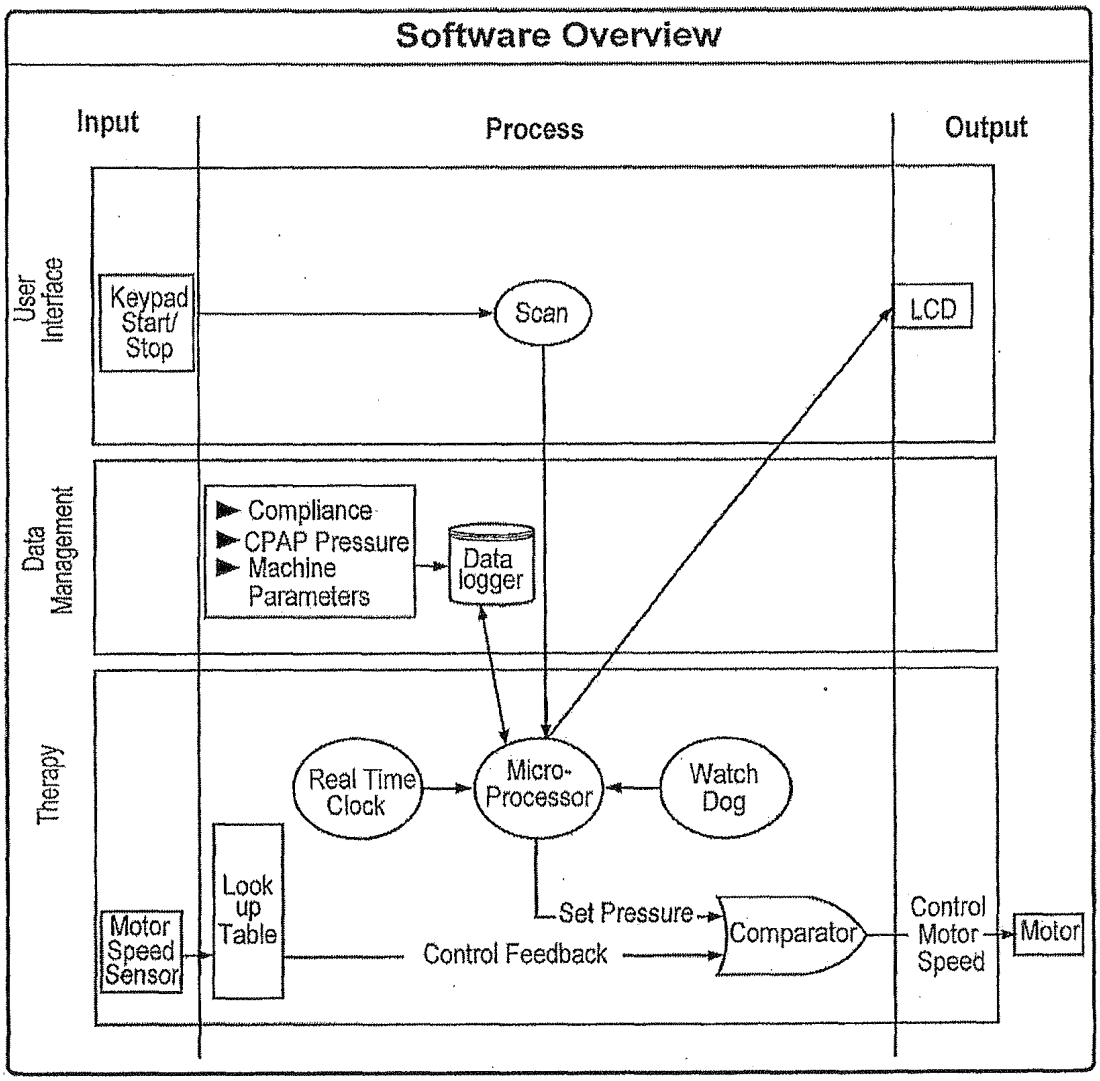

Software Overview
Input
Process
Output
User Interface
Keypad Start/ Stop
Scan
LCD
Data Management
Compliance
CPAP Pressure
Machine Parameters
Data logger
Therapy
Real Time Clock
Micro-Processor
Watch Dog
Look up Table
Motor Speed Sensor
Set Pressure
Control Feedback
Comparator
Control Motor Speed
Motor

Fig. 23

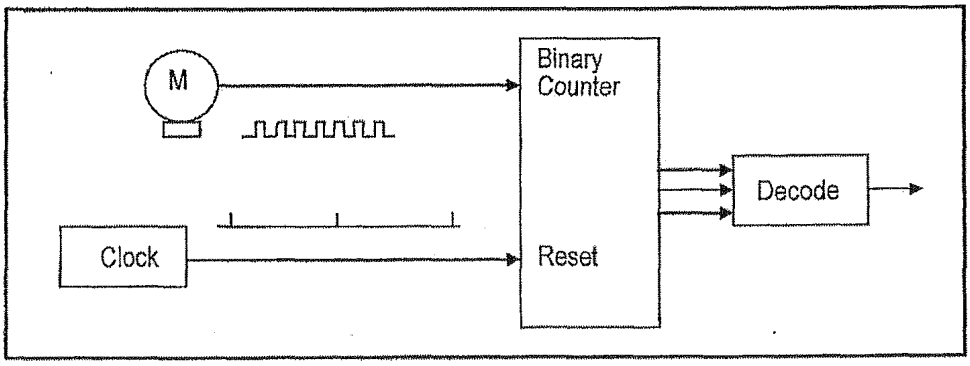

M
Binary Counter
Decode
Clock
Reset

Fig 24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001173

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. ***A61M 16/00*** (2006.01) ***A61M 16/16*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: A61M 16/---, A62B 7/--, 9/-- IPC & keywords: (CPAP, apnea, SDB, OSA, humidifier, moisture, temperature, heat, detect, sensor, monitor, measure, control, regulate, adjust, microprocessor, program) and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/0182386 A1 (MEIER) 23 September 2004 See the entire document.	1-40
X	GB 2338420 A (FISHER & PAYKEL LIMITED) 22 December 1999 See the abstract, figure 2, and page 5, lines 24-30.	1-40
P, X	WO 2006/015416 A1 (RESMED LIMITED) 16 February 2006 See the abstract, figure 1, paragraphs [0018]-[0034].	1-40
A	EP 1197237 A2 (GOTTLIEB WEINMANN GERÄTE FÜR MEDIZIN UND ARBEITSSCHUTZ GMBH + CO.) 17 April 2002 See entire document.	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 November 2006	16 NOV 2006
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **SUE THOMAS** Telephone No : (02) 6283 2454

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001173

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2000/027457 A1 (RESMED LTD.) 18 May 2000 See the entire document.	
A	US 5537997 A (MECHLENBURG et al.) 23 July 1996 See the entire document.	
A	AU 71978/98 B2 (745216) (RESMED LIMITED) 14 March 2002 See the entire document.	
A	WO 2004/043528 A1 (FISHER & PAYKEL HEALTHCARE LIMITED) 27 May 2004 See the entire document.	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001173

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See annexed sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.: **1-40**

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2006/001173

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1 and 2 are directed to a CPAP device wherein humidification control is performed by a microprocessor of the CPAP device without requiring a separate humidification control chip. It is considered that having humidification control performed by a microprocessor of the CPAP device without requiring a separate humidification control chip comprises a first distinguishing feature set.

- Claims 3 to 40 are directed to a CPAP device and a method of controlling a humidifier of the device, wherein the device comprises a flow generator with a microprocessor with an analog-to-digital converter, a humidifier detachedly coupled to the flow generator, and a temperature sensor in communication with the humidifier and adapted to provide a voltage signal to the microprocessor, wherein the microprocessor controls the power supply to the humidifier based on the output of the temperature sensor. It is considered the provision of a temperature sensor in communication with the humidifier and adapted to provide a voltage signal to the microprocessor, wherein the microprocessor controls the power supply to the humidifier based on the output of the temperature sensor comprises a second distinguishing feature set.

- Claims 41 to 45 are directed to a method of controlling a humidifier of a CPAP device. The method includes the steps of controlling a heating element in the humidifier with command signals from the controller, sensing a temperature of a fluid in the humidifier with a sensor and transmitting signals back to the controller, establishing an acceptable operating range for the transmitted signal, and determining whether the signal is within the acceptable operating range. If the signal is within the range, the signal is treated as being indicative of the humidifier fluid temperature and the signal is used to control the heating element. If the signal is outside of the acceptable operating range, the controller determines the humidifier to be unavailable. It is considered that the above method steps comprise a third distinguishing feature set.

- Claims 46 to 51 are directed to a liquid crystal display comprising a character domain including a plurality of segments and a control circuit to selectively energize one or more of the segments on a time share basis. At least two of the segments are driven serially. It is considered that the provision of an LCD with a character domain including a plurality of segments and a control circuit to selectively energize one or more segments on a time share basis, wherein at least two segments are driven serially comprises a fourth distinguishing feature set.

- Claims 52 to 56 are directed to a controller and an LCD for an electromechanical device comprising a control processor to control a plurality of functions, an LCD having inputs to receive control signals, and a common domain in the LCD for displaying alphanumeric characters wherein each common domain includes a plurality of segments and the segments are made up of liquid crystal sandwiched between a common electrode and a segment electrode. Each segment can be activated by applying voltages to the common electrode and the segment electrode, wherein each common and segment electrode has an input port on the LCD. The controller has a duty cycle for applying power to the common and segment electrodes and applies power during the duty cycle to a first segment and then to a second segment. It is considered the features described above comprise a fifth distinguishing feature set.

[See Supplemental Box]

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

- Claims 57 to 59 are directed to a method for controlling a CPAP device set to operate at a predetermined voltage. The method includes the steps of monitoring a main power supply voltage, comparing the monitored voltage to the predetermined voltage, and producing a control signal based on the comparison of the two voltages. It is considered that these method steps comprise a sixth distinguishing feature set.

- Claims 60 to 63 are directed to a CPAP device comprising a flow generator including a microprocessor, a motor provided to the flow generator, and a digital circuit to detect RPM of the motor. The digital circuit includes a clock timer, a counter unit, and a decoder configured to generate a signal that is indicative of RPM as a function of time. It is considered that the provision of a CPAP device with a digital circuit to detect motor RPM, wherein the digital circuit includes a clock timer, a counter unit, and a decoder configured to generate a signal that is indicative of RPM as a function of time comprises a seventh distinguishing feature set.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

Each of the abovementioned groups of claims has a different distinguishing feature and they do not share any feature which could satisfy the requirement for being a special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2006/001173

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2004182386	DE	10139881	WO	2003/018096		
GB	2338420	AU	35087/99	DE	19928003	FR	2779965
		IT	TO990527	JP	2000024109		
WO	2006/015416	NONE					
EP	1197237	DE	10049869				
WO	2000/027457	AU	15326/00	EP	1126893	US	6591834
		US	6745768	US	7040317	US	2003168065
		US	2004226561	US	2006137687		
US	5537997	AU	37975/99	AU	60474/96	CA	2196918
		CA	2357148	EP	0777507	US	5540219
		US	5655522	US	5947115	WO	1996/040335
AU	745216	AU	71978/98	AU	78989/98	CA	2294260
		EP	0989875	US	6397841	WO	1998/057691
WO	2004/043528	AU	2003278647	CA	2505504	EP	1562663
		US	2006130836				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX